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Potential Human Study Populations for Non-Ionizing (Radio Frequency) Radiation Health Effects

JRB Associates, Inc.
McLean, VA

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POTENTIAL HUMAN STUDY POPULATIONS FOR NON-IONIZING (RADIO FREQUENCY) RADIATION HEALTH EFFECTS

by

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16. ABSTRACT

This research project was initiated to identify potential human populations for future epidemiological studies of the health effects of radio frequency radiation. Through a literature search and contacts with various groups and organizations, numerous occupations and applications of radio frequency radiation (RFR) were identified and evaluated for their suitability for further study. Many populations were eliminated early because their potential exposure to RFR was too limited or data necessary for epidemiological research were unavailable. Eight populations were evaluated in detail and appear to satisfy many of the criteria for epidemiological research and could be useful study groups in an investigation of the health effects of non-ionizing radiation. The eight potential study populations are: RF heat sealer operators, HF (high frequency) tube welder operators, medical diathermy operators in Veterans Administration hospitals, medical diathermy operators in rehabilitation facilities, school children located near broadcasting towers, state policemen, security guards, and radar technicians.

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FORWARD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory participates in the development and revision of air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is primarily responsible for providing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

Pursuant to the mission of the laboratory to investigate the effects of non-ionizing radiation on human health, this project was undertaken to identify population groups which might be suitable for future epidemiological studies and to evaluate these study populations in terms of established criteria for epidemiological research.

F.G. Hueter, Ph.D.
Director
Health Effects Research Laboratory

ABSTRACT

This research project was initiated to identify potential human populations for an epidemiologic study of the health effects from exposure to non-ionizing radiation.

A literature search was undertaken to determine occupational and public applications of radiofrequency radiation (RFR) that involved human exposure. This search indicated dozens of occupations and applications that were grouped into three major areas: industrial and commercial; medical and therapeutic; communications and navigation. For each category, information was then sought on the devices that emit RFR, the occupational and trade groups working with these devices, and the facilities and procedures involved in the use of these devices. To obtain and verify this information, nearly 250 occupational and trade organizations were contacted and more than 50 experts on RFR were interviewed. In addition, hundreds of documents were reviewed.

After each application of RFR was verified, potentially exposed population groups associated with that application were identified. Some populations were eliminated early because their potential exposure to RFR was too limited or data necessary for epidemiological research were unavailable. Eight potential study populations were identified: RF heat sealer operators, HF tube welder operators, medical diathermy operators in Veterans Administration hospitals, medical diathermy operators in rehabilitation facilities, school children located near broadcasting towers, state policemen, security guards, and radar technicians. These populations were then studied further to assess their suitability for epidemiological research. Information was obtained concerning the size of each population, the availability of exposure data, the availability of personal and medical records, the availability of a control group, and the possibility of organizational cooperation in a subsequent study. The eight populations identified satisfy many of the criteria for epidemiological research and could be useful study groups in an investigation of the health effects of non-ionizing radiation.

This report was submitted in fulfillment of Contract No. 68-02-3470 by JRB Associates under sponsorship of the U.S. Environmental Protection Agency. This report covers the period September 29, 1980 to March 29, 1981, and work was completed as of July 17, 1981.

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CHAPTER 1

INTRODUCTION

In 1864, James Maxwell of Cambridge University suggested the existence of electromagnetic radiation. He theorized that electromagnetic energy radiated in a wavelike form at the speed of light. This energy was caused by the electric charges produced by the simultaneous movement of electric and magnetic fields. Maxwell's theory was substantiated in 1888, when Heinrich Hertz demonstrated that electromagnetic radiation was emitted from an electric spark gap. In 1901, Guglielmo Marconi adapted electromagnetic energy for use in wireless telegraphy. By the 1920s, wireless telegraphy had led to the development of the radio and the radiotelephone. Equipment that generated highly directional beams of radiofrequency radiation (RFR) permitted the development of radar during World War II.

Today, RFR is generated by numerous types of specialized electron tubes, oscillators, klystrons, and magnetrons. RFR technology is used in many activities in our daily lives: we cook our food in microwave ovens, and we watch television programs that are broadcast by satellite to millions of viewers around the world. As described in this report, RFR has industrial and commercial, medical and therapeutic, and communications and navigation applications. These various applications have developed because of the scientific properties of electromagnetic energy.

The term radiofrequency designates that portion of the electromagnetic spectrum with frequencies from 0 to 300 gigahertz (GHz) and with wavelengths ranging up to 100,000 centimeters. Figure 1 shows the range of frequencies associated with certain applications that use RFR.

Radiofrequency, a form of energy, elicits various responses in the matter with which it interacts. The specific response depends on characteristics of both the energy and the matter. Radiofrequency energy is non-ionizing radiation, because it is not energetic enough to induce molecular ionization in matter. RFR may, however, cause other molecular changes.

When RF energy is absorbed, it effects an increase in the kinetic energy of the molecules of the absorbing material. This kinetic energy causes the molecules to vibrate or oscillate millions of times per second, which produces heat. Hence, when biological tissue absorbs RFR, the main response is a temperature increase. If the heat load is great enough or if it is not reduced or dissipated, damage to the tissue may occur.

Studies of the biological effects of exposure to RFR have demonstrated thermally induced tissue damage in laboratory animals. However, neither thermal nor non-thermal effects of chronic exposure to low levels of RFR have been conclusively demonstrated in humans.

Further information is required to determine the human health effects of chronic exposure to low levels of RFR. An epidemiological study could provide the data needed to make this determination. To assess the possibilities for such investigation, this report documents the research conducted to identify

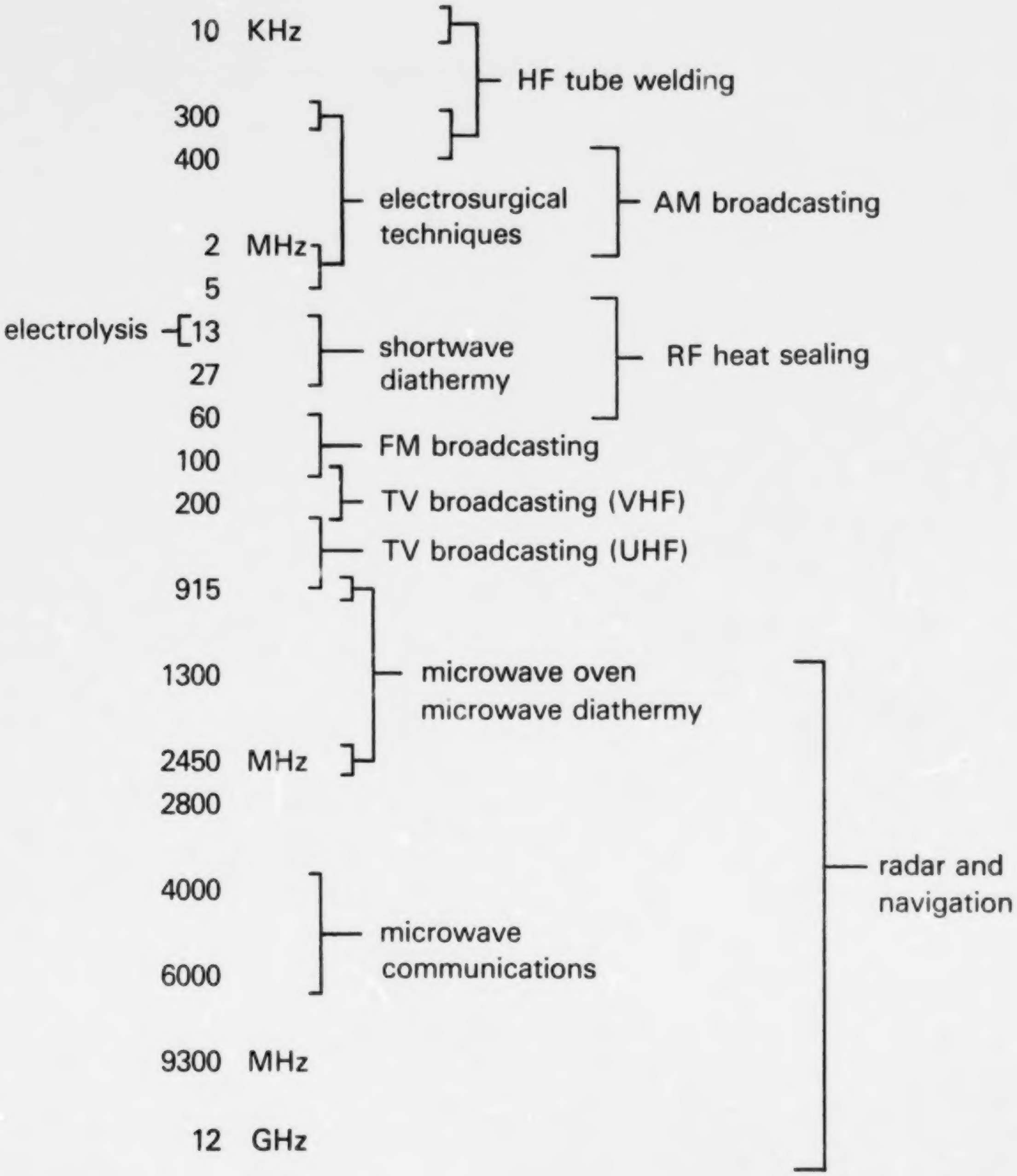
10 KHz
300
400
2 MHz
5
13
27
60
100
200
915
1300
2450 MHz
2800
4000
6000
9300 MHz
12 GHz
HF tube welding
electrosurgical techniques
AM broadcasting
electrolysis
shortwave diathermy
RF heat sealing
FM broadcasting
TV broadcasting (VHF)
TV broadcasting (UHF)
microwave oven
microwave diathermy
radar and navigation
microwave communications

Figure 1. Frequencies of Applications Using RFR

potential human populations for study. The discussion presents the conclusions reached as a result of the research.

CHAPTER 2

CONCLUSIONS

This research effort consisted of identifying devices emitting radiofrequency, determining occupational and public applications of these devices, and assessing potentially exposed population groups to determine their suitability, for epidemiological research. The criteria used in assessing the groups were:

- Size of sample, with a minimum requirement of 200 persons
- Availability of exposure data
  - Actual use of RF-emitting device
  - Documentation of brand of equipment used
  - Documented cases of the type of device leaking radiofrequency radiation (RFR)
  - Potential for measuring leakage
  - Documentation of actual measurements performed at various facilities
- Availability of personal data
  - Occupational/personnel records
  - Medical records or other health status indicators: clinics, physician, insurance, or health maintenance organizations
- Availability of suitable control group
- Indication of the sample group's cooperation in the research.

Eight populations, listed below, were identified as being potentially suited for an epidemiological study:

- RF heat sealer operators
- HF tube welder operators
- VA hospital physical therapists
- Physical therapists in rehabilitation facilities
- School children near broadcast towers
- State police officers
- Security guards
- Radar technicians.

Although none of these populations satisfies all of the evaluation criteria, each population has unique or outstanding characteristics in one or more areas that set it apart from the other groups. The next section identifies these characteristics and makes recommendations.

CHAPTER 3

RECOMMENDATIONS

Each of the eight populations identified in the preceding section may be suitable for an epidemiological study of the health effects of exposure to RFR. As table 1 indicates, each of the groups has distinctive characteristics. The selection of a study population among the eight populations depends on the Environmental Protection Agency's priorities, the desired study emphasis (environmental or occupational), the types of exposure of greatest concern, time and monetary considerations, and the public policy and environmental health issues EPA seeks to address.

The best study population in terms of realistic environmental exposures would be the school population located near broadcasting towers. Whereas this population may be particularly suited to determining behavioral effects of low level exposures, it would be unsuited for near-term assessment of carcinogenic effects.

The State police officers and RF plastic heat sealer operators would be the prime study groups of the occupationally exposed populations because some documentation of exposure levels is already available.

Security guards, who use walkie-talkies may be the best population for an epidemiological investigation of ocular effects including cataracts, because high field strengths have been measured near the eye.

Union support of a study would provide an excellent data base of personal and medical records. Union support has already been indicated for both the radar technicians and HF tube welder operators.

If the cooperation of another Federal agency and the potential sharing of costs, data, and/or staff are desirable, then the VA Hospital physical therapists, or the RF plastic heat sealer operators, or the radar technicians would be the most likely candidates.

The selection of the best population for an epidemiological study from among these alternatives depends upon the areas of greatest concern to the Environmental Protection Agency.

Table 1. DISTINCTIVE CHARACTERISTICS OF THE STUDY POPULATIONS

Population	Distinctive Characteristics
RF Plastic Heat Sealer Operators	● Extremely large population ● Generically documented exposures ● Limited study undertaken by NIOSH - Many facilities identified - Many exposure measurements taken - Guaranteed cooperation at NIOSH request
HF Tube Welder Operators	● Most facilities are unionized - United Steelworkers of America - Union health care clinics - Union records - Assured cooperation
VA Hospital Physical Therapists	● Generically documented exposures ● Standardized records - Medical - Personnel ● VA cooperation ● VA Hospital employee health clinics
Physical Therapists in Rehabilitation Facilities	● Generically documented exposures ● Employee health clinics
School Children near Broadcast Towers	● Environmental exposures ● Generically documented exposures ● A variety of parameters for possible consideration ● Potential for public concern and interest
State Police Officers	● Large and stable population ● Generically documented exposures ● Extensive and complete work and medical histories ● Records standardized within a State ● Potential for very long-term exposure
Security Guards	● Large population ● Documented exposure ● Potential for very long-term exposure
Radar Technicians	● Large population ● Great interest and support indicated by FAA, unions, and others ● Standardized records and equipment

CHAPTER 4

RESEARCH METHODS

The purpose of this research project was to identify potential populations for an epidemiological study of the health effects of long-term exposure to radiofrequency radiation (RFR). To achieve this purpose, we devised a research strategy of literature searching and information gathering, integrated with data analysis. The plan was to:

- Identify a study universe of all possible applications of RFR that could involve human exposure
- Gather all the information we could find on the elements of the universe
- Analyze these data and focus on those exposed groups that best meet the criteria specified for epidemiological study populations.

The essential processes underlying the plan were the continuous expansion of our information base accompanied by the focusing of our study universe. This chapter chronologically describes how we carried out our study plan.

Successful literature searching depends on the precise definition of the research problem. However, in this case the identity of the subject of the literature search--the exposed populations--was unknown at the start. Therefore, we had to choose a frame of reference for the search that would enable us to get to the desired end. We chose the applications of RFR as this frame of reference.

Our first task, then, was to review the literature to identify all known applications of RFR. This would be our study universe. We were specifically searching for information on:

- All devices using RFR
- All applications of these devices
- All occupations and labor categories involved in the manufacture or use of these devices
- All public applications of these devices that would result in environmental exposures.

As our starting point, we visited several libraries in the Washington, D.C., area and searched the standard references listed in table 2. In addition, we searched files of the National Library of Medicine's MEDLINE System. Literature searching is a broadening process, and our list of information sources grew concurrently with our list of applications.

Table 2. STANDARD REFERENCE SOURCES CONSULTED

Source	Type of Information
National Trade and Professional Associations and Labor Unions of the United States and Canada, 1980	Current lists of organizations
Dictionary of Occupational Titles	Brief descriptions of specific occupations
Modern Plastics Encyclopedia	Technical description of RF heat sealing
BLS Industry Wage Surveys: Furniture, household wood (#1930) Pulp and paper products (#2008) Synthetic fibers (#1975) Miscellaneous plastic products (#1914) Basic iron and steel (#2064) Motor vehicles and parts (#1912) Communications (#2071) Electrical appliance repair shop (#2067)	Industrial surveys
Occupational Diseases: A Guide to Their Recognition (HEW Report No. 77-181)	Introduction to biological effects of RFR
NIOSH/OSHA Current Intelligence Bulletin #33: RF Heat Sealers and and Heaters	Specific information on heat sealers and health effects; lists occupational groups and manufacturers
Thomas Catalog of American Manufacturers	Lists names, addresses, phone numbers of manufacturers and potential users of RF equipment
Microwave Product Data Directory of 1980-1981	Lists manufacturers of RF equipment and components
Electronics Market Data Book	Overview of electronics industry
Dun and Bradstreet	Lists all business organizations with sales over $500,000/year
Occupational Outlook Handbook	Projects employment in various occupations
Census of Manufacturers	Lists manufacturers

(Continued)

Table 2. (Continued)

Source	Type of Information
Standard Industrial Classification Handbook	Official source of codes to categorize industries and occupations
NIOSH National Occupational Hazard Survey	Estimates workers exposed to RFR
Occupational Injuries and Illnesses in U.S. by Industry	Lists incidences, but not related to occupations
National Center for Health Statistics	Includes health statistics for general population

During this initial searching, it gradually became clear that the applications could be organized into three general areas:

- Industrial and commercial
- Medical and therapeutic
- Communications and navigation.

It was, therefore, useful and convenient to organize our research into these three broad categories.

Through literature searching, we broadened our base of information to compile a list of nearly 50 applications of RFR. We had identified our study universe, but the progession of our research from applications to populations required additional information. For example, one or more of our sources stated that RFR is used to dry potato chips. That statement alone was not sufficient for our purposes. We had to know what type of RFR-emitting device was used, how that device operated, what occupations and labor categories were involved in the manufacture or use of the device, and whether any applications could result in environmental exposure. Therefore, our information base had to be expanded to a greater level of specificity.

Literature searching continued throughout the project, but to answer specific questions about the applications required a different information-gathering technique. By consulting the 1980 edition of the National Trade and Professional Associations and Labor Unions of the United States and Canada, we identified the appropriate organizations that might be associated with each of the applications on the list. These groups included:

- Trade associations
- Professional associations
- Labor unions
- Equipment manufacturers
- Organizations representing industries
- Users of RF devices.

All the groups contacted are listed in appendices A, B, and C. Most of the contacts were by telephone, and the information received was recorded on worksheets designed for this project.

Recalling our earlier example, to find out about the application of RFR in drying potato chips, we contacted the Potato Chips/Snack Food Association and the Potato Association of America. We learned that RFR is not, in fact, used to dry potato chips. This information, although negative, was critically important to our overall effort: obviously, if RFR is not used in a specific process or procedure, no associated populations are in danger of exposure. When such information was received, we focused our study universe by eliminating that application.

However, often the organizations contacted verified applications of RFR. With this information, we were able to identify labor categories, occupational groups, and trades potentially exposed to RFR. Through these contacts, we sometimes obtained most of the data necessary to evaluate a potential study population:

- Size of target population
- Availability of exposure data
- Availability of personal records
- Potential for a suitable control group
- Determination of cooperation in an epidemiological study.

By analyzing the identified populations in terms of the above data items, we again narrowed our study universe.

For example, we verified the application of RFR to induce hyperthermia as treatment for cancer. However, through contact with the relevant organizations and medical experts, we learned that this therapeutic application of RFR is still in the experimental stage, and thus its actual clinical use is limited. Therefore, the population of physicians who administer such treatments would probably not be large enough to constitute a suitable study group. In addition, we learned that exposure data would be difficult to obtain for this population.

Although, in cases like this, we did verify applications of RFR, we nevertheless narrowed our study universe because of the findings that:

- The particular application of RFR was so limited as to preclude the identification of a suitable population

- The population identified could not be characterized in terms of the data identified above.

Through the continuing processes of gathering information and analyzing the data, we identified facilities and locations where RF devices are used and people are exposed to this type of radiation.

At this point, we believed that we had a good grasp of both the study subject and the direction of our own research effort. We then contacted experts recognized in the field of RFR and Government agencies doing related research. Appendix D lists the experts who were contacted. We asked them for information about their research and for advice on our own study. Several of the experts suggested specific populations for study, some of which we had already identified.

What remained to be done was to focus on each of the eight identified populations and characterize them in detail, according to specific criteria. We had originally developed an extensive set of qualifications criteria. However, early on we recognized that, short of conducting the actual survey for the epidemiological study, we would not be able to attain the level of detail for our information that we had envisioned. The evaluation criteria that we used to characterize the suggested study populations represented a somewhat elaborated version of the criteria that we used all during the study to evaluate the populations associated with the identified applications of RFR. These criteria were:

- Minimum sample size of 200
- Availability of exposure data
    - Actual use of a RF-emitting device
    - Documentation of brand of equipment used
    - Documented cases of the type of device leaking RFR
    - Potential for measuring leakage
    - Documentation of actual measurements performed at various facilities
- Availability of personal data
    - Occupational/personnel records
    - Medical records or other health status indicators: clinic, physician, insurance, or health maintenance organization
- Availability of suitable control group
- Evidence of intent to cooperate.

Once again, the task of focusing the study universe required the gathering of more data. We contacted a number of additional organizations to characterize the remaining populations in detail. These organizations included:

- Manufacturers of RF radiation equipment
- Agencies regulating the equipment
- Agencies researching exposure to this equipment
- Facilities using the equipment
- Various authorities who compile the type of data needed for each population.

In addition, we visited facilities actually using this equipment.

The information acquired from all these sources enabled us to characterize each population with all its inherent advantages and disadvantages as a population for epidemiological study. Although the criteria were essential for focusing the study, often a population had one special attribute that made it a very likely study candidate. Finally, we obtained all the necessary information to progress from our study universe of applications to the desired endpoint of the research effort--the identification of recommended populations for an epidemiological study of the health effects of long-term exposure to RFR.

This report gives the results of our research by documenting the expansion of the information and the consequent narrowing of the study universe. In chapter 5, the study universe is industrial and commercial applications of RFR; in chapter 6, it is the medical and therapeutic applications; and in chapter 7, communications and navigation applications. Each of these chapters progresses from the universe of applications to the identification of possible study populations. The detailed characterization of each of these populations is presented in chapter 8.

CHAPTER 5

INDUSTRIAL AND COMMERCIAL APPLICATIONS

This chapter examines the research progression from the study universe of industrial and commercial applications of radiofrequency radiation (RFR) through to the identification of possible study populations. In this report, the term industrial describes the use of RF equipment to manufacture other products. The term commercial describes an end product of a manufacturing process.

Literature searching and information gathering revealed the following study universe of industrial and commercial applications of RFR:

*Cooking of food
Commercial baking
Meat processing
Potato chip drying
Thawing of frozen food
Concrete curing
Concrete shattering
Oil shale heating
Plastic pipe fabrication
Plastic container production
*Vinyl plastic fabrication
Plastic lamination
Drying of photographic film
*Steel tube welding
Urethane foam heating and curing
Wood drying
Leather drying
*Textile drying
Pulp and paper drying
*Foundry core drying
Drying of adhesives
Drying of insulation
*Curing of rubber
Heating of rubber
*Drying of synthetic fibers

To identify possible study populations associated with these applications, we contacted the appropriate professional associations, trade unions, and occupational organizations to find out about the use of RFR in the industries they represent. In addition, we contacted experts in the field, relevant Government agencies, manufacturers, and factories. Appendix A lists the sources contacted. We verified the use of RFR in those applications marked with an asterisk. Some of these applications, however, were ultimately eliminated from the study universe because the use of RFR is so limited as to preclude the identification of feasible study populations.

Those applications without asterisks were eliminated from the study universe because RFR is not used. This narrowing of the study universe and concurrent expansion of our information base are described in section 5.1.

The analysis of all this information resulted in the identification, from the original study universe, of two applications that seemed to have potentially suitable populations associated with them. By studying these applications, vinyl plastic fabrication and steel tube welding, in detail, we were able to identify two study populations, thereby progressing from applications to populations. The associated populations are broadly described in terms of size and availability of data. Section 5.2 discusses how the information base was expanded still more to reach the research end point of exposed populations.

5.1 EVOLUTION OF THE STUDY UNIVERSE

By searching standard reference books, Government publications, and scientific articles, we identified numerous industrial and commercial applications of RFR that constituted the original study universe. To progress beyond this simple list of reported applications, we contacted professional associations, trade unions, and occupational organizations to inquire about the use of devices that generate RFR in the particular industries they represent.

Tables 3 through 6 list the trade associations that were contacted in each of four general industrial categories. All associations in each category provided the same information: RFR is not used for any purpose in their industry. Some associations informed us that past attempts had been made to use RFR for certain processes or operations, but these attempts were experimental and were never developed into regular production operations. Therefore, the applications identified in the tables were eliminated from the study universe.

The information provided by the organizations listed in tables 3 to 6 was critical to our research effort, because it resulted in the narrowing of the study universe down from the original 25 applications to nine. At the same time that we were eliminating some applications, we verified other applications of RFR.

Several of the applications in the original study universe involved heating and drying operations associated with the use of RF heaters. When we contacted the professional associations that represent the industries involved with drying textiles and fabrics, heating and curing of rubber, and the drying of foundry cores, we learned that RF devices may be used for these purposes, but their use is limited. An individual factory or plant may have a single RF device used for a specific drying operation, but this type of equipment is not used by the industry as a whole. Table 7 lists the limited industrial applications of RF heaters and the various trade associations that were contacted to obtain this information.

An association representing manufacturers of commercial and consumer microwave ovens was also contacted and is listed in table 7. These ovens are used only by commercial food service establishments and private consumers to cook and warm food; they have no other purpose or application.

The following sections discuss the limited use of industrial RF heaters and commercial microwave ovens, as well as possible study populations among the users of these devices.

5.1.1 Industrial RF Heaters

Although we had general information about the industrial and commercial use of RF devices, we needed technical data about the devices and information on how they are used in production processes. We contacted manufacturers of industrial RF heating equipment and commercial microwave ovens and learned that rubber, textile, synthetic fibers, and foundry industries use this

Table 3. ELIMINATION OF FOOD PROCESSING APPLICATIONS

Associations	Potato Chip Drying	Commercial Baking	Frozen Foods Thawing	Meat Processing
National Food Processors		X	X	
American Frozen Food Institute			X	
Food Processing Machinery & Supplies Association		X		X
Potato Chips/Snack Foods Association	X			
Potato Association of America	X			
National Frozen Food Association			X	
Bakery Equipment Manufacturers		X		
Association of Meat Packers				X
National Independent Meat Packers				X

Table 4. ELIMINATION OF CONSTRUCTION MATERIALS APPLICATIONS

Associations	Concrete Curing	Concrete Shattering	Oil Shale Heating	Wood Drying
Timber Products Manufacturing				X
National Forest Products				X
National Concrete Masonry Association	X	X	X	
American Concrete Institute	X	X	X	
Hardwood Plywood Manufacturers Association				X

Table 5. ELIMINATION OF PLASTIC PRODUCTION APPLICATIONS

Association	Plastic Pipes	Plastic Containers	Plastic Laminates	Urethane Foam
National Association of Plastic Fabricators		X	X	
Plastic Pipe and Fittings Association	X			
Plastic Pipe Institute	X			
Organization of Plastic Processors		X	X	
Urethane Foam Contractors				X
Urethane Institute				X
Association of Industrial Metallizers and Laminators			X	
Plastic Container Manufacturers' Association		X		
Plastic and Metal Product Manufacturers	X		X	
Plastic Soft Materials Manufacturers Association		X	X	

Table 6. ELIMINATION OF CURING AND DRYING APPLICATIONS

Associations	Adhesives	Leather	Photo Film	Pulp and Paper	Insulation Materials
Carpet and Rug Institute	X				X
Adhesive Manufacturers Association	X				
Adhesive and Sealant Council	X				
Tanners Council of America		X			
Suede and Leather Refinishers of America		X			
Photographic Society of America			X		
Photographic Equipment Manufacturers of America			X		
American Paper Institute				X	
American Pulpwood Association				X	
Association of Pulp and Paper Industries				X	X

Table 7. APPLICATIONS THAT INVOLVE LIMITED USE OF RFR

Associations	Rubber Curing	Textile Drying	Foundry Core Drying	Commercial Microwave Cooking
International Microwave Power Institute	X	X	X	X
Institute of Electrical Electronic Engineers	X		X	X
Rubber Manufacturers' Association	X			
American Apparel Manufacturers		X		
American Association for Textile Technology		X		
American Textile Manufacturers Institute		X		
Clothing Manufacturers' Association		X		
Foundry Equipment Manufacturers			X	
Association of Home Appliance Manufacturers				X

equipment. Therefore, we contacted rubber, textile, fiber and foundry companies and asked if they used RF heating equipment. Table 8 lists both the manufacturers and the potential users of the RF equipment that we contacted.

All these companies verified that RF devices are not widely used for their heating and drying operations. Single RF heaters may be used by individual factories, but the majority of factories in an industry do not use these devices. For example, of the ten potential users of industrial RF heaters contacted, only one company used such a device and only for a few days per week.

Manufacturers of industrial RF heaters reported that there are two basic types: batch-type microwave heaters and large-scale units made for continuous operation as part of a production line. The batch-type heaters are similar to the household microwave oven, but are much larger and generate much higher intensities of microwave radiation. They emit microwave radiation at frequencies of 915 MHz or 2,450 MHz, depending on the size, shape, and composition of the material to be heated. Typically, only one person operates the unit. Separate quantities or batches of a material are introduced into the unit and heated to a specific temperature. Batch-type units are used by some rubber factories to pre-heat chunks of rubber before the pressure molding process. Some foundries use these units to heat and de-gas foundry cores or molds. Seven manufacturers of batch-type units were contacted, and all reported that they sold about ten units per year; they estimated that approximately 500 units are currently used in the United States.

The other type of RF heater is the continuous operation unit, which is usually incorporated into the production line and is part of the automated manufacturing process. Most of these units are designed to generate RF frequencies between 10 and 27 MHz, although some may emit microwave frequencies of 915 or 2,450 MHz. They are fully automated and require only one operator. These continuous operation heaters can be used to heat thin-layer materials and to dry coatings onto thin materials. These devices are used by some textile and synthetic fiber companies to dry continuous sheets of cloth or strands of fibers. They can also dry bulky objects, such as foundry molds. The manufacturers informed us that each device is custom-designed for the particular needs of the customer and is thus very expensive. Each company sells only three to five units per year, with an estimated total number of fewer than 300 units in operation in the United States.

The manufacturers are responsible for testing and monitoring both types of RF heaters to ensure compliance with Federal Communications Commission (FCC) frequency regulations and Occupational Safety and Health Administration (OSHA) safety guidelines for personnel exposure. Before the units are sold, a team of two or three individuals performs several leakage tests and frequency stabilization measurements. Each device must be frequency-stabilized, so it does not "drift" off the assigned frequency, and it should not emit stray radiation which would result in personnel exposures in excess of 10 mW/cm^2. The manufacturers stated that compliance with the OSHA guidelines is not difficult, since the equipment is designed to emit less than 5 mW/cm^2 of stray radiation.

Once the units are sold, the customer has full responsibility for all

Table 8. COMPANIES CONTACTED TO DETERMINE LIMITED APPLICATIONS

Companies	Rubber Heating	Textile Drying	Fiber Drying	Commercial Ovens	Foundry Core Drying
MANUFACTURERS					
Litton Corporation				X	
Nobart Corporation				X	
White-Westinghouse				X	
Gerling-Moore	X	X			
Speco Corporation		X			
PSC Corporation	X	X			X
Despatch Oven Company	X	X			
Cober Electronics			X		
Reeves Electronics	X		X		
USERS					
Firestone Rubber Company	X				
Goodyear Rubber Company	X				
Armada Rubber Company	X				
Rubber & Plastic Company	X				
Synthetic Thread Company			X		
Engineered Yarns Inc.			X		
Engineered Monofilaments			X		
Hooker & Saunders Textiles		X			
J-Lenco Foundry Company					X
Beardsley-Piper Foundry					X

maintenance, which appears to be minimal. Monitoring or testing for stray radiation is usually not done unless OSHA takes a measurement as part of a compliance inspection. These RF heaters are never or only rarely tested for leakage once they leave the manufacturer.

5.1.2 Commercial Microwave Ovens

Several manufacturers of household microwave ovens were contacted about how the ovens are manufactured and tested for radiation leakage. Thousands of ovens are mass-produced each year and sold to numerous establishments that prepare food. The commercial microwave ovens are like the household microwave ovens, except that they are designed for "heavy duty" use. A manufacturer may produce several different models that have different external features, but all of the ovens are essentially the same.

As the completed ovens come off the production line, each is measured for leakage of microwave radiation. BRH regulations limit the radiation leakage to less than 1.0 mW/cm^2 at the time of manufacture and a maximum of 5.0 mW/cm^2 after the unit is sold. However, the manufacturers indicated that once the ovens leave the factory, they are not required to be monitored again. The ovens are made of solid-state components, so maintenance and repairs are minimal. When needed, repairs are done while the ovens are turned off by a trained person from the manufacturer.

5.1.3 Possible Study Populations: Operators or Users of Industrial Heaters and Commercial Ovens

Once we verified the actual, albeit limited, use of RF devices in heating and curing operations and in the preparation of food, the next step was to determine what populations might be associated with their use. We tried to describe the populations identified in terms of size and availability of data.

Persons who operate or work with industrial RF heaters were identified as a possible study population. A relatively small number of batch-type heaters and even fewer continuous operation heaters are in use today. The devices are not widely used by any particular industry. Those factories that do use there devices usually have only one unit, and it may not be used every workday. These units are automated, so that usually one individual is required to operate each unit. During operation, only one or two persons are in a position to be exposed to any stray RFR. Although a total population of 500 to 700 operators of this equipment does exist and the potential for exposure may be present, the group is not readily available for study because each operator is working at a different factory, under different conditions, and using devices of different designs to manufacture different materials and products. In short, this population is not suitable for study, since it is too small, too diverse, too difficult to locate, and the exposure data and workplace conditions cannot be standardized.

Similar difficulties were encountered in attempting to find a suitable study population among users of commercial microwave ovens. Although thousands are in operation, each food preparation establishment has only one or two ovens and only a few people use them. The cooks and kitchen help do not keep track of the time they spend near an operating microwave oven. In general, users of microwave ovens are not suitable for study because there are too few individuals at any one establishment, conditions of exposure are variable, and the exposures that may occur are sporadic and impossible to document.

Individuals who test RF heaters or microwave ovens for leakage also do not represent a suitable study group, because they are too few in number. There are only about 20 manufacturers of this type of equipment and each employs two or three persons as testers for RF leakage. Although these technicians may be exposed to radiation from ovens they are testing, the total number of these workers is too small and the level of exposure is too low for a feasible study. Furthermore, these individuals may have other work responsibilities and do not monitor for leakage on a full-time basis. Similarly, persons who repair RF heaters and microwave ovens also are not a suitable study group because the size of the total population is too small. More importantly, the devices are turned off whenever repairs are being made, thus minimizing the potential for substantial exposure. If exposures were to occur inadvertently, the level of exposure would not be known.

The above populations associated with the limited use of RF devices were found to be unsuitable for epidemiological study. None could be satisfactorily characterized according to the specified criteria.

5.2 PROGRESSION FROM APPLICATIONS TO STUDY POPULATIONS

All of the information gathered up to this point had served to narrow the industrial and commercial study universe to two applications: vinyl plastic fabrication and steel tube welding. Several professional organizations that represent these two industries reported that RF devices are definitely used in these industries and, moreover, are widely and extensively used. RF heat sealers are used in plastic fabrication, and HF tube welders are used to make steel tubing. The following associations verified these applications of RF devices:

- Vinyl plastic fabrication
  - International Microwave Power Institute
  - Chemical Workers Union
  - Waterbed Manufacturers Association
  - International Ladies Garment Workers Union

- Steel tube welding
  - Pipe Fabrication Institute
  - Welded Steel Tube Institute
  - United Steelworkers of America
  - American Pipe Fitters Association.

We contacted the manufacturers and users of RF heat sealers and steel tube welding equipment listed below to obtain information about the different types of devices manufactured, the number sold, the operating characteristics of these devices, and how they are used or operated. We also visited a tube manufacturing company that used three HF welding units to observe the operation of these devices.

- Vinyl plastic fabrication
  - Solidyne Corp.
  - J. A. Callanan Co.
  - Batson Machinery
  - Marlo Plastics
  - Best Seal Corp.
  - Plastic Services
  - Tracies Corp.
  - Meda Plast
  - Classic Products
  - Blair Plastics

- Steel tube welding
  - Thermatool Corp.
  - Republic Steel Co.
  - Donovan Steel Tube Co.
  - Callier Tube Co.
  - Alpha Tube Co.
  - Higbie (ITT) Tube Co.
  - Babcock & Wilcox
  - Copperweld Tubing
  - Daily Corp.
  - Tuesday Ind.
  - Armco Tube Co.
  - Bethlehem Steel Tubing
  - Bundy Corp.

The following sections examine the use and operation of RF plastic heat sealers and HF tube welders, devices which use RF radiation. In relation to the use of these devices, monitoring requirements, exposure potential, and potentially exposed population are described.

5.2.1 RF Plastic Heat Sealers

The vinyl plastic industry is the largest user of RF devices. The most common type of device is the RF heat sealer, which is used to fuse or melt pieces of vinyl plastic to each other. Thousands of vinyl fabrication factories employ these devices to make a wide assortment of plastic and plastic-covered products, including vinyl plastic bags and pouches, notebook covers, plastic novelties, and waterbed mattresses. These devices can also be used for silk-screening, embossing plastic decals onto cloth, and curing glues in certain wood lamination and veneer processes.

RF heat sealer devices operate within the frequency bands assigned by the FCC for industrial, scientific, and medical purposes, i.e., the ISM bands.

The two frequencies most commonly used by RF heat sealers are 13.56 and 27.12 MHz, although some devices may operate at frequencies from 6 to 60 MHz. The RF energy is generated through two parallel plates that serve as electrodes. The plastic material to be sealed is put between these two electrodes, the plates are hydraulically pressed together, and a pulse of RFR is emitted between the two electrodes. The pulse of RF energy produces rapid heating of the plastic, which fuses together the overlapping edges of plastic. The electrodes are then moved apart, and the sealed plastic is removed. This entire operating cycle takes about 30 to 40 seconds, but the actual pulse of RFR lasts for only about 3 to 10 seconds, depending on the size and thickness of the plastic to be sealed. Therefore, the operator receives intermittent RF exposure and not a continuous exposure.

Several varieties of RF heat sealing devices are used by the plastics industry. The most commonly employed units resemble large sewing or stitching machines and usually require only one operator. They are used mainly to make small plastic articles that can be individually heat sealed. Another type is the shuttle tray heat sealer. Pre-fabricated pieces of plastic are arranged on a tray, which is then moved into position between the RF electrodes. These units can process greater quantities of plastic than the sewing-machine type of units and usually require two operators. The turntable unit is a third type of RF heat sealer used by the plastic fabrication industry. Four or five workers at assembly areas around a circular turntable prepare the plastic pieces. The table revolves and, while one piece is being sealed, the other pieces are assembled into position.

The type and number of RF heat sealers used in a factory depend on the type of product and the quantity to be manufactured. A small plastics factory may have only two to five heat sealers, while a large shop may use 50 to 60, or more, devices. These can range from the small sewing-machine units that require only one operator to much larger units that require up to seven workers to operate. The sealers are usually grouped together in one general work area to facilitate the fabrication process, since an article sealed on one device may need further processing on another machine.

The manufactures of the RF heat sealers are required by OSHA and the FCC to inspect and monitor the devices for stray RFR and frequency stability (Baranski, 1980 personal communication). The devices should not leak RFR which would result in personnel exposures in excess of the 10 mW/cm^2 OSHA guideline. The manufacturers informed us that compliance is not a problem, since the heat sealers are designed to emit less than 5.0 mW/cm^2 of stray radiation. Excess radiation leakage may occur, however, once the device is installed and operating at the factory. Monitoring for leakage is no longer the responsibility of the manufacturer, and the company that purchased the RF device may never survey for stray radiation. It is possible that many of the RF heat sealers currently in use in the United States have never or have only infrequently been surveyed for stray radiation.

All RF heat sealer devices must also be frequency-stabilized to prevent drifting into other frequencies that have not been approved for use by the FCC. Each RF heat sealer must be registered with the FCC at the time it is sold or within 30 days of the sale. The FCC requires for each RF device:

- Name and address of manufacturer
- Name and address of company that purchased the unit

- Size and kilowatt power of the unit
- Operating frequency
- Operating characteristics of each device.

In addition, the FCC registration files indicate the number of RF devices that each registering company owns and operates. These FCC files are a source for identifying companies that use RF heat sealer devices.

About 20,000 RF heat sealers are currently in use in the United States (NIOSH/OSHA, 1979). RF sealers tend to be sturdy pieces of equipment, and many of them have been in operation for 10 to 15 years or longer. The National Institute for Occupational Safety and Health (NIOSH) estimated that from 30,000 to 40,000 workers are involved with the operation of these devices (NIOSH/OSHA, 1979).

Several studies have demonstrated that operators of RF heat sealers can be exposed to RF intensities greater than 10 mW/cm^2 and 200 V/m for the electric (E) field and 0.5 A/m for the magnetic field. Stuchly and others (1980a and b) of National Health and Welfare, Canada, found the highest exposures occurred at the head and chest levels of operators using the sewing-machine type of RF heat sealers. For 33 sewing-machine type units that were surveyed, the average E field level at the head and chest was 28 mW/cm^2 (325 V/m), and the average H field level was 11 mW/cm^2 (0.54 A/m). The range of E field exposures was 0.01 to 124 mW/cm^2, and the range for H field exposures was from 0.05 to 74 mW/cm^2. Nearly 40 per cent of the heat sealers surveyed exposed the operators to more than 10 mW/cm^2 of RF radiation.

Conover and others (1978) of the Physical Agents Branch of NIOSH conducted a similar survey of exposures from more than 80 RF plastic heat sealers. Near field measurements were taken at various anatomical locations on the operator while the machines were in normal operation. All measurements were adjusted for the regular duty cycles of the machines. Magnetic and electric field exposures were highest at the neck, chest, and waist. More than 60 percent of the RF sealers emitted electric field strengths greater than the ANSI guideline of 200 V/m. In addition, more than 29 per cent of the sealers exceeded the ANSI guideline of 0.5 A/m for magnetic strength exposure.

The Surveillance, Hazards Evaluation, and Field Study group of NIOSH is currently planning a reproductive effects study of women who operate RF heat sealers in plastics factories. The study will examine the fetal mortality and morbidity rates in infants of women who operated RF heat sealers while they were pregnant. Over the past two years, NIOSH has identified a number of plastics factories that use 20 or more RF heat sealers, and they have surveyed some of these to determine the extent of leakage and the level of exposure received by operators. Results of these preliminary surveys indicated that about 55 per cent of the RF heat sealer operators were exposed to RF intensities exceeding the OSHA standard of 10 mW/cm^2. Some of the operators were exposed to electric field intensities as high as 1,480 V/m and equivalent power densities of 800 mW/cm^2 (Matusow 1980). These are only preliminary results, but may indicate significant occupational exposure to RF radiation in the plastic fabrication industry.

NIOSH is in the process of identifying and selecting female RF heat sealer operators for this study. NIOSH used the FCC registration files initially to identify and characterize plastics factories that had the required number of RF heat sealers. Other agencies interested in studying occupational exposure to RF radiation could use the same identification procedures as NIOSH. Since NIOSH has already examined the appropriate FCC files, other agencies may be able to obtain this information and avoid duplication of research efforts. However, we suggest expanding on NIOSH's proposed reproductive study. Health effects other than fetal mortality and morbidity should be considered and the study population could be expanded to include all operators of RF heat sealers, not just pregnant women.

5.2.2 High-frequency (HF) Tube Welding

As stated previously, HF radiation at a frequency of 400 Khz is used to weld much of the metal tubing produced in the United States. HF welding is especially suited for continuous high-speed production of round, shaped, finned, or flexible tubing, and can be used for both longitudinal and spiral welding processes. A wide variety of ferrous and non-ferrous tubing can be welded using HF, and it greatly increases the speed of tube production, compared to conventional electrical resistance welding. In addition, certain lightweight metal I-beams and other structural materials can be made with HF welding techniques.

Metal tubing is formed and welded in large devices called tube mills, which are part of the automated production line in a tube factory. The mills range from 50 to 100 feet in length, depending on the diameter of the tubing to be produced. Flat metal strips are introduced continuously into one end of the tube mill and are guided through a series of pressure rollers that form it into a tubular shape. The two open edges, or seams of the tube, then pass directly beneath a pair of electrodes, or the entire tube passes through an induction coil. HF radiation at a frequency of 400 KHz is generated by the pair of electrodes or the induction coil. The current of HF energy is absorbed by the open edges of the seam, which immediately increases the surface temperature of the metal along the seam. The edges of the seam are then pressed together and they fuse, forming a continuous weld along the length of the tube.

Although these tube mills are large and may be in use continuously, they are fully automated and require only a few workers to operate and supervise the entire welding process. Three workers are usually required: one person observes and controls the introduction of the metal strips into the mill, another worker is at the other end observing the output of finished tubing, and the third worker, located near the center, operates and controls the actual welding process. This operator, standing at a small control panel located about two to four feet from the HF electrodes, observes the welding process and regulates the quality of the weld by making adjustments in the hydraulic pressure of the rollers, welding speed, and the HF current generated by the electrodes.

Manufacturers of the HF generators and electrodes used in the tube mills informed us that each HF unit is registered with the FCC. The units are made of solid-state components and are frequency stabilized, so repairs and adjustments are minimal. The OSHA safety standard limiting radiation leakage to 10 mW/cm^2 is not applied to HF welding units, since the operating frequency of 400 KHz is below the range of the standards. Therefore, except for the information in the FCC files, no information is available on the extent of leakage or the potential for operator exposure to HF radiation from these units.

The manufacturers of HF tube welders and producers of metal tubing estimated that about 1,000 HF welding units are in operation in the United States. They also estimated that approximately 3,000 persons may be involved with the operation of these units. These figures are subjective estimates, since no information about HF tube welding was found in the available literature.

This chapter has traced the expansion of information about the elements in the study universe of industrial and commercial applications. Through literature searching and contacting various organizations and manufacturers, we verified the applications that do, in fact, use RFR. This resulted in the focusing of the study universe. Additional information described the RF devices used and their operation. By finding out where these devices are used, we identified people who could be exposed to RFR. Certain populations were eliminated, because they do not possess the characteristics specified for an epidemiological study population. The study universe was finally narrowed down to two applications. The analysis of these two applications led to the identification of two possible study populations, RF heat sealer operators and HF steel tube welder operators. These populations are discussed in chapter 8.

CHAPTER 6

MEDICAL AND THERAPEUTIC APPLICATIONS

This chapter examines the research progression from the study universe of medical and therapeutic applications of radiofrequency radiation (RFR) to the identification of possible epidemiological study populations. Literature searching and information gathering revealed the following study universe of medical and therapeutic applications of RFR:

Tissue-fixing
Blood-warming
Sterilizing and drying of pharmaceuticals
Pathology
* External hyperthermia
* Surgical implant hyperthermia
* Doppler radar monitoring
* Lung-water measurements
* Diathermy
* Electrosurgery
* Electrolysis.[1]

To identify possible study populations associated with these applications, we contacted the appropriate professional organizations to inquire about the use of RF devices by the professionals they represent. In addition, we contacted medical experts, relevant Government agencies, and manufacturers. Appendix B lists the sources contacted. We verified the use of RFR in those applications marked with an asterisk. Some of these applications were ultimately eliminated when information revealed that use of RFR is so limited as to preclude the identification of feasible study populations. Those applications without asterisks were eliminated from the study universe because they do not involve the use of RFR. Section 6.1 describes the concurrent processes of expanding our information base and narrowing the study universe.

The analysis of this information resulted in the identification, from the original study universe, of three applications that seemed to have suitable populations. By further studying these applications--diathermy, electrosurgery, and electrolysis--we were able to identify potential study populations, thereby progressing from applications to populations. These populations are described in terms of size and availability of data. Only diathermy unit operators are recommended as a study population. Section 6.2 describes the further expansion of the information base to identify exposed populations.

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[1] Although electrolysis is a cosmetic procedure, we have considered it as a medically related application.

6.1 EVOLUTION OF THE STUDY UNIVERSE

By searching standard reference books, Government publications, and scientific articles, we identified the medical and therapeutic applications of RFR that constituted the original study universe. We obtained additional information by contacting professional and trade associations and academic institutions to inquire about the use of RF equipment by the professionals and students they represent. Some of this information enabled us to eliminate certain applications from the study universe.

The following professional associations indicated that RFR is not used in the medical and therapeutic procedures identified:

- Tissue-fixing
    - American Society of Clinical Pathologists
    - American Association of Pathologists, Inc.
    - American Osteopathic College of Pathologists, Inc.
- Blood-warming
    - American Association of Blood Banks
    - American Red Cross Blood Bank Program
- Sterilizing or drying of pharmaceuticals
    - Pharmaceutical Manufacturers Association
    - National Association of Pharmaceutical Manufacturers
- Pathology
    - Georgetown University Hospital Pathology Department
    - American Society of Clinical Pathologists
    - American Association of Pathologists, Inc.
    - American Osteopathic College of Pathologists, Inc.

All of the above associations provided the same information: RFR is not used by members of their profession or industry. Some associations informed us that there had been attempts to use RFR in blood-warming and tissue-fixing. These attempts, however, were mainly experimental and were never developed into widely accepted techniques or procedures. Therefore, these four applications were eliminated from the study universe.

At the same time that we were eliminating some applications, we verified other applications of RFR. Several medical experts indicated that physicians are using RFR for diagnostic purposes and to treat cancer. Many of the diagnostic and cancer therapy techniques are still in the research stage, and their clinical use is limited. Table 9 lists the individuals who were contacted and the type of information they provided.

In the microwave method of lung-water measurements, the changes in the dielectric properties of lung tissue are used to detect changes in the tissue's water content. The monitoring of arterial wall movement by microwave Doppler radar has been pioneered by S.S. Stuchly and colleagues (1978) at the University of Ottawa in Canada. This experimental procedure uses the measured Doppler shift to identify arterial displacement.

Table 9. LIMITED APPLICATION OF RFR RADIATION IN MEDICAL DIAGNOSIS AND CANCER THERAPY

Experts	Lung-Water Measurements	Doppler Radar Monitoring	External Hyperthermia	Implant Hyperthermia
Ernest Albert George Washington University Medical Center Washington, D.C.			X	X
Don R. Justesen VA Medical Center Kansas City, MO	X	X	X	X
Madgy Iskander Electrical Engineering Dept. University of Utah	X	X		
Carl H. Durney Electrical Engineering Dept. University of Utah	X	X		
S.S. Stuchly Electrical Engineering Dept. University of Ottawa		X		

Some cancers and various forms of muscular and skeletal disabilities can be treated by using hyperthermia. Localized tissue hyperthermia can be produced with the application of RFR. Several different procedures have been developed to produce localized tissue hyperthermia. These techniques include the use of RFR at the industrial, medical, and scientific frequencies of 13.56 and 27.12 MHz. Surgical implant hyperthermia is another experimental form of cancer treatment. Microwave radiation-emitting devices are inserted into tissue surgically or through a body orifice. These methods have been developed because of the difficulty in treating deep tissues by external microwave radiation. Implanted radiators for cancer therapy are being tested at frequencies of 915 and 2,450 MHz. A third method, that of hypodermically injecting microwave radiation-emitting devices, is also being designed and tested.

The diagnostic and therapeutic applications of RFR discussed here are promising techniques that are attracting wide interest. Nevertheless, the RF equipment being used, as well as the techniques, are still experimental. The Federal Register proposed rule (BRH 1980) on the microwave diathermy products performance standard states: "Microwave diathermy is currently under investigation regarding effectiveness for cancer treatment, it is not clear whether microwave diathermy procedures for cancer therapy would conform to the proposed standard."

Once we verified the actual use of RF devices in these diagnostic and therapeutic applications, the next step was to identify associated populations. Physicians and research scientists employ RF equipment to perform these procedures. Because these procedures are still experimental, the numbers of persons using them and the facilities in which they are in use are very small. There are also difficulties in determining operator exposures to RFR during the actual procedures. Obtaining a suitable human study population exposed to RFR from any of the limited applications discussed here is most unlikely at this time.

6.2 PROGRESSION FROM APPLICATIONS TO STUDY POPULATIONS

All of the information gathered up to this point had served to narrow the study universe to three applications: diathermy, electrosurgery, and electrolysis. The following professional associations and schools informed us that RFR is widely used by physical therapists during diathermy treatments, by physicians during surgery, and by electrologists for permanent hair removal:

- Diathermy
    - American Physical Therapy Association
    - National Association of Physical Therapists
    - American Chiropractic Association
    - American Academy of Physical Medicine and Rehabilitation
    - Commission on Accreditation of Rehabilitation Facilities
    - Northern Virginia Community College, Physical Therapy Department
    - Howard University, Physical Therapy Department

- Electrosurgery
    - American Medical Association
    - American Nurses Association

  - Association of Operating Room Nurses, Inc.
  - Association for Advancement of Medical Instrumentation
  - American Dental Trade Association
  - American College of Obstetricians and Gynecologists
  - American Association of Gynecological Laparoscopists
  - American Society for Gastrointestinal Endoscopy
  - American Veterinary Medical Association
  - American Dental Association

- Electrolysis
  - American Electrolysis Association
  - Kree Institute of Electrolysis
  - Eleanor F. Roberts Institute.

The information these associations and schools provided was not specific enough for our purposes, so we contacted the manufacturers of diathermy, electrosurgery, and electrolysis equipment listed below. We inquired about the different types of devices manufactured, the number produced, the operating characteristics, the number of people involved in production and/or testing of the devices, and the exposure potential for these production and/or testing personnel.

- Diathermy
  - Mettler Electronics, Inc.
  - Birtcher Corporation
  - Burdick Corporation
  - R.J. Lindquist Company
  - R.A. Fischer and Company

- Electrosurgery
  - Neomed, Inc.
  - Sybron, Inc.
  - Electro-Medical Systems (EMS)
  - Valleylab
  - Cameron-Miller, Inc.
  - Parkell, Inc.
  - Ellman, Inc.
  - Whaledent, Inc.

- Electrolysis
  - Kree International
  - Sudonna Manufacturing Company, Inc.
  - Instatron Company
  - Proteus, Inc.

From the information received from these manufacturers, we determined that during the production and/or testing of RF equipment, the potential for significant exposure to non-ionizing radiation is minimal, if indeed it exists at all. Therefore, persons who are involved in the production and/or testing of electrosurgical units, diathermy units, and epilators should most likely be excluded from study because they probably are not exposed to non-ionizing radiation.

The following sections describe diathermy, electrosurgery, and electrolysis, procedures which use RFR. In relation to the procedures, we examine monitoring requirements, exposure potential, and potentially exposed populations.

6.2.1 Diathermy

According to the information contained in the Food and Drug Administration's (FDA) proposed rule (BRH 1980), approximately 15,000 diathermy units have been sold in the U.S., with usage estimates of up to 49 million diathermy treatments per year. Physical therapists, chiropractors, and physicians are some of the many medical professionals who operate diathermy units. The units may be located in a hospital, a clinic, a rehabilitation facility, a chiropractor's office, or a physician's office. Therefore, estimating the total number of individuals who operate diathermy units is difficult, if not impossible. It is the operator who may be exposed to stray RFR that is emitted by diathermy units.

Diathermy is defined by Tabers Cyclopedic Medical Dictionary (1973) as "the therapeutic use of high frequency current to generate heat within some part of the body." Both diathermy modalities, shortwave and microwave, involve the transfer of high frequency, high intensity electromagnetic energy to the tissues to be heated. The energy from the diathermy unit passes through the skin into the subcutaneous tissues, where it meets resistance, converting the energy to heat. Diathermy produces a deeper tissue temperature rise than do other heat sources, such as hot packs or whirlpools. Diathermy is used when deep heat is required, when an increase in the circulation or metabolic process is desired, and when relief of chronic pain by relaxation of skeletal muscles is needed. The length of a diathermy treatment is generally 20 minutes, but this varies with the part of the body and the condition or ailment being treated.

Shortwave diathermy is used to apply deep heat to large areas of the body. Under optimal conditions, this diathermy modality penetrates the tissue to a maximum depth of three centimeters. Shortwave diathermy units operate at frequencies of 13.56 or 27.12 MHz. Although these frequencies are called shortwave by people in the field, they are in the RF region and are actually RF frequencies.

Shortwave diathermy units generate either electromagnetic field or electric field energy. A shortwave diathermy treatment using electromagnetic field heating, also called induction field heating, can be given by the drum electrode or the cable electrode procedure. The drum electrode is the least complicated diathermy to apply and is used primarily to treat small areas. The ~~cable~~ cable electrode procedure involves the wrapping of the cable around elbows, knees, or other parts of the arms or legs. This cable electrode can also be adjusted into a pancake configuration to apply deep heat to the lower back.

With electric field heating, also called condensor field heating, a strong electric field is generated with either two air-spaced electrodes or two condensor pads. When the electrode that stores energy is filled to capacity, energy is transferred to the patient and then to the low-potential electrode; the patient becomes part of the electrical circuit. With the air-spaced electrodes, the greater the distance between the electrode and the tissue being treated, the greater the depth of penetration. The closer the electrode to the tissue being treated, the lesser the depth of penetration, but the greater the sensation of warmth. With condensor pads, spacing is built into the pads and can only be adjusted by placing layers of towels between the pads and the patient.

The other mode of medical diathermy is microwave, which operates at frequencies of 915 or 2,450 MHz. This diathermy modality penetrates the tissue to a maximum depth of five centimeters. With microwave diathermy, however, depth of penetration depends upon the thickness of the subcutaneous fat, since fatty tissue readily absorbs microwave radiation, impeding penetration to underlying tissue.

Microwave diathermy units have two types of applicators or directors. The round director radiates from the circumference and is used to treat bony parts of the body or convex surfaces. The rectangular director radiates energy from its center and is used to treat smooth parts of the body or flat and concave surfaces.

The Food and Drug Administration, Bureau of Radiological Health, is currently reviewing the status of microwave diathermy. A proposed performance standard for microwave diathermy products, published in the Federal Register (BRH 1980), states: "A performance standard is needed for microwave diathermy products because of the failure of the currently available products to provide an adequate indication of the degree of energy delivered to the patient, assure adequate heating, provide appropriate safety features, and limit the levels of microwave radiation outside of the immediate treatment area." Tests conducted by FDA's Bureau of Radiological Health on microwave diathermy equipment currently in use have indicated that the most frequently used applicators radiated excessive stray energy toward untargeted regions of the patients' bodies and the surrounding environment (Ruggera 1980). Microwave diathermy units are not presently produced in the U.S. (BRH 1980), but they are being imported at the rate of approximately 50 per year and are used in clinics throughout the country.

Many companies manufacture or have manufactured shortwave and/or microwave diathermy equipment. Stuchly and colleagues (1980c) of the University of Ottawa surveyed shortwave and microwave diathermy units being used in Canada. They identified 34 manufacturers of shortwave diathermy units. The Canadian manufacturers are required to inspect and monitor each diathermy unit for stray microwave/shortwave radiation and frequency stability. The Canadian standard limits the amount of stray radiation to 1 mW/cm^2/hour. The American National Standards Institute (ANSI) recommends that no diathermy unit in the U.S. leak microwave/shortwave radiation in excess of 10 mW/cm^2. This recommendation is currently under review by the BRH, and a final report is planned on this subject for 1981. According to current practices, the manufacturer's responsibility ends when the unit is sold. Once the device is in operation at a clinic or hospital, it may never be monitored for leakage of stray radiation. Therefore, many of the shortwave and microwave units currently in use in the United States have never, or only rarely, been surveyed or monitored for stray radiation. Radiation leakage exceeding the 10 mW/cm^2 recommendation may be occurring unknowingly in many shortwave and microwave diathermy units (Ruggera 1980).

All diathermy devices must also be frequency-stabilized to prevent drifting into frequencies not specified for medical use by the Federal Communications Commission (FCC). Each diathermy unit sold in the United States must be registered with the FCC within 30 days of purchase. The FCC requires the following information for each shortwave or microwave diathermy unit: name and address of manufacturer, name and address of unit purchaser, the size and kilowatt power of the unit, the operating frequency, and the operating characteristics of each device. In addition, the FCC registration files indicate the number of shortwave or microwave units that each registering facility owns and operates. These FCC files are an excellent source for identifying medical facilities that use shortwave or microwave diathermy units.

Several studies have demonstrated that operators of microwave/shortwave diathermy units are being exposed to stray radiation during treatment. To determine the stray radiation emitted by a microwave diathermy unit, leakage testing with phantoms was conducted by Bassen and others (1979) of FDA's Bureau of Radiological Health. Two conventional non-contact applicators (Burdick types B and E) were surveyed. High leakage (35.5 and 44.0 mW/cm^2) occurred when input power to the applicators was increased to deposit 235 W/kg in the phantom muscle material. These data indicated that high leakage is most likely occurring during actual microwave diathermy treatments.

Ruggera (1980) of FDA's Bureau of Radiological Health surveyed physical therapists during shortwave or microwave diathermy treatment of patients in New York City hospitals in July 1978. The six shortwave diathermy units operated at a frequency of 27 MHz, and the three microwave units operated at a frequency of 2,450 MHz. Stray radiation during both shortwave and microwave treatments was measured approximately ten centimeters in front of the operator's eyes and waist.

For the six shortwave units evaluated, with the operator standing by the unit console, the maximum electric (E) and magnetic (H) field strengths measured were 250 V/m and 0.37 A/m, respectively, which is equivalent to free-space power densities of 16.6 mW/cm^2 and 8.3 mW/cm^2. When the operator moved closer to the shortwave applicators, the exposure levels were much higher. For the three microwave units evaluated, with the operator standing by the unit console, the maximum power density measured was 1.3 mW/cm^2, which is equivalent to 70 V/m and 0.19 A/m in free space. These data suggest that both shortwave and microwave applicators emit radiation in directions other than those intended for treatment.

These studies indicated that during microwave/shortwave diathermy treatment, stray radiation is being emitted, allowing for exposure of unintended tissue of the patient and of the operator of the unit (physical therapist, chiropractor, physician, etc.). Therefore, operators of diathermy equipment are a potential study population for examining the health effects that have been associated with exposure to RFR. This potential study population is discussed in detail in Chapter 8.

6.2.2 Electrosurgery

Electrosurgery involves the passage of high (radio) frequency current through tissues to make surgical incisions, control bleeding, and destroy tissue, without mechanical pressure. The electrosurgical unit (ESU) is a small radio transmitter that operates at frequencies ranging from 0.3 to 5.0 MHz, depending upon the manufacturer and model. A high frequency current is transmitted through an active electrode and is returned through a dispersive electrode. The patient is positioned between the two electrodes, and the electrosurgical current passes through the patient to complete the electrical circuit. Since the cells of body tissue are composed primarily of fluid, which conducts electricity, the electrosurgical current flows readily through the patient's body. As the electrosurgical current passes through the patient's body, the cells attempt to resist the flow of the current, which causes the content of the cells to be heated. The traumatic, instantaneous heating forces the cells to burst, creating an electrosurgical incision. An active cutting electrode, the electronic knife or scalpel with a sharp contact point, concentrates the cutting current in the tissue.

Electrosurgical coagulation involves the nonexplosive heating of a cell until its fluid contents evaporate through the cell's outer membranes, dehydrating the cell. The coagulating forceps (active electrode) are kept in constant contact with the tissue, conducting the current to deeper cells.

Electrosurgical units are assembled by specially trained personnel. The manufacturers, like all manufacturers of medical devices, are regulated by the Food and Drug Administration. All manufacturers have quality control personnel to monitor for stray RFR and check frequency stability. Excess radiation leakage may occur later, however, once the units are in operation in hospitals and physicians' offices, where monitoring is the responsibility of biomedical engineering departments and the individual physicians. It is possible that many of the RF electrosurgical units currently in use in the U.S. have rarely or never been surveyed or monitored for stray radiation. As a result, radiation leakage exceeding 10 mW/cm^2 may be undetected in many electrosurgical units.

All electrosurgical units must also be frequency-stabilized to prevent drifting into other frequencies not specified for medical use by the FCC. Each electrosurgical unit sold in the U.S. must be registered with the FCC within 30 days of purchase. The FCC files, which include the number of electrosurgical units each hospital or office owns and operates, are an excellent source for identifying medical facilities that use electrosurgical units.

Electrosurgical units are widely used in the U.S. in both dentistry and medicine. Dental electrosurgery is performed in the dental office on ambulatory, fully-clothed patients and involves nonlife-threatening procedures that do not require concurrent use of electronic monitoring devices (JADA 1980). The dental electrosurgical unit, as described by the ANSI/American Dental Association (ADA) Specification Number 44, consists of a generator of high RF electrical currents, cables, and electrodes for delivering the RF energy to the patient's mouth, and circuiting and devices to control the duration and intensity of the application (ANSI/ADA 1979).

This ANSI/ADA (1979) standard gives the minimal requirements for dental electrosurgical devices that "operate in a 1.5 to 4.0 MHz frequency range and have a maximum power output capability of 100 watts or less, but not less than a maximum capability of 50 watts, and are used principally in the oral cavity for performing clinical dental electrosurgery procedures." The proposed rule, published in the Federal Register (BMD 1980), describes the risk to the health of the patient as related to "extensive heat induced damage that may occur surrounding the surgical site due to improper or inadequate performance of the device when the cutting process is prolonged." The proposed rule does not mention any health risk associated with RFR exposures of dentists who operate electrosurgical units.

Medical electrosurgery is performed in a hospital operating room where life-threatening conditions may require concurrent use of monitoring or therapeutic electronic devices (JADA 1980). RFR from medical electrosurgical units can interfere in other nearby electrical devices, such as electrocardiographs, electroencephalographs, and pacemakers.

Medical electrosurgical units are found in almost every hospital operating room and in some physicians' offices. General surgeons, neurosurgeons, and obstetrician/gynecologists are among the specialty groups who use electrosurgical units. Estimating the number of individuals who operate electrosurgical units is very difficult.

As described, the units are used during general surgical and various delicate surgical procedures to make incisions and coagulate blood vessels. Endoscopic examinations of body cavities may also involve the use of an electrosurgical unit. Such endoscopic procedures are bronchoscopy, colonoscopy, gynecological laparoscopy, and upper gastrointestinal panendoscopy.

Gynecological laparoscopy is of interest for identifying a population exposed to RFR. Obstetrician/gynecologists use this technique to perform tubal ligations, which account for one-third of all female sterilizations in the U.S. It is also used by obstetrician/gynecologists during microsurgery to reconstruct fallopian tube tissue, i.e., to reverse the sterilization process. In tubal ligations, an electric current, generated by an electrosurgical unit, is used to cut and coagulate fallopian tube tissue. The procedure can be performed in the physician's office or in a hospital operating room for minor surgery, and can be completed in approximately 20 minutes.

The operating laparoscope, used to perform the tubal ligation through a small incision, must have a small diameter. Therefore, the RF current is directed through an inner active electrode separated by only thin insulation from the metal telescope wall. This separation is so small that as much as one-third to one-half of the current passing through the inner active electrode may be coupled to the metal telescope wall (Hays 1979). Hence, the distance from the inner active electrode, which is emitting RF radiation, to the physician's (operator's) eye is very small. Since the development of cataracts has been associated with exposure to RFR, this group of physicians should be examined further to determine their potential for study.

The American Association of Gynecological Laparoscopists (AAGL) has approximately 4,000 members. The association membership list is available from the AAGL chairman, Dr. Jordan M. Phillips. The AAGL surveyed its membership about laparoscopic practices and complications in 1976 (Phillips et al. 1978) and again in 1979 (Phillips et al. 1980). In 1979, the respondents reported 3,613 requests for reversal of sterilization and performed 1,507 reversals, using microsurgical techniques. The number of laparoscopic sterilizations increased from 77,103 in 1976 to 88,986 in 1979. This increase may reflect the increased survey response rate rather than an actual increase in the number of laparoscopic sterilizations performed.

Gynecological laparoscopists are one of many medical specialty groups potentially exposed to RFR from electrosurgical units. Ruggera (1977) of FDA's Bureau of Radiological Health measured equivalent power densities of 265 mW/cm^2 at a distance of 16 centimeters from the unit. These data indicated that under typical operating conditions, medical electrosurgical units may be emitting excess RFR. Another health risk may be associated with the electromagnetic interface with other electronic devices used in patient monitoring and life-support equipment.

We surveyed Veterans Administration (VA) Hospitals to obtain more information on the use of RF electrosurgical units in operating rooms. Table 10 summarizes the information received. All the hospitals contacted had at least one electrosurgical unit per operating room. The biomedical engineering department of each hospital provided information on electrosurgical unit manufacturers and models. None of these biomedical engineering departments monitor the electrosurgical units for stray RFR. One biomedical engineering technician estimated that, on the average, electrosurgical units are activated for about six to seven hours per day, whether or not they are being used.

The information we gathered indicates that dental and medical electrosurgical units are emitting RFR during dental surgical, general surgical, and endoscopic procedures, allowing for exposures of operators (surgeons, gynecologists, obstetricians, dentists) of the units. One of these specialty groups perhaps should be considered as a potential study population for examining the health effects associated with exposure to RFR. However, as previously noted, the operating room is a unique environment where many other electronic devices and systems are being used simultaneously. The interaction of these variables would make it difficult to isolate the effects of RFR in an epidemiological study. Therefore, general surgeons and other physicians who operate electrosurgical units in the hospital operating room can be eliminated as a potential study population.

Doctors and dentists who operate electrosurgical units in their offices are also exposed to RFR. However, these individuals are not readily available for study because each one is working in a different location, under different conditions, with varying rates of equipment use. Therefore, doctors and dentists who operate electrosurgical units in their offices are most likely unsuitable for study since these populations are too divided, too difficult to locate, and the exposure data and work environment cannot be standardized.

Although electrosurgery involves the exposure of several populations, no population is suggested for further study. Exposure data do exist, but the populations are too fragmented and working conditions are too diverse.

Table 10. SURVEY OF VETERANS ADMINISTRATION HOSPITALS' USE OF ELECTROSURGICAL UNITS

VA Hospital	Estimated Number of Staff Surgeons and Residents	Number of Operating Rooms	Number of Electrosurgical Units and Manufacturers
Phoenix, AZ	19	5	7 Valleylab SSK
Tucson, AZ	45	5	5 Valleylab SSK
Washington, DC	Not available	10	9 Neomed 3000a
Baltimore, MD	27	4	4 3M 3 Birtcher
Hines, IL	Not Available	9	2 Bovie 2 EMS 2 Birtcher 3 3M
Loma Linda, CA	10	5	5 Valleylab SSE2K 2 Valleylab SSE3

6.2.3 Electrolysis

Electrolysis is a cosmetic process to remove unwanted hair permanently from any part of the body. A professional electrologist is licensed or certified by an accredited school of electrology. Electrologists use devices called shortwave epilators to direct a tiny, split-second impulse of RF radiation through an insulated needle of extremely fine wire into the hair root to destroy it. Shortwave epilators generate RFR and operate at a frequency of 13.56 MHz, producing either elongated or square waves. Square waves rise and drop rapidly, causing substantial power at the peak, which coagulates the hair root more completely and causes less sensation to the client. The elongated waves rise slowly and drop slowly, causing the client more pain.

A number of electrolysis centers and clinics in the Washington, D.C., metropolitan area were contacted to determine the extent of shortwave epilator usage. Table 11 summarizes the information obtained.

The FCC requires the manufacturers of shortwave epilators to inspect and monitor each unit for RFR and frequency stability. The manufacturers that we contacted had safety approval from Underwriters Laboratory (UL), and the Canadian Standards Association (CSA).

All shortwave epilators must also be frequency-stabilized to prevent drifting into other frequencies not specified for industrial, medical, or scientific use by the FCC. Each shortwave epilator sold in the U.S. must be registered with the FCC within 30 days of purchase. The FCC registration files are an excellent source for identifying centers and clinics that use shortwave epilators.

Shortwave epilators are operated, in general, by trained, licensed or certified electrologists, in beauty shops and electrolysis centers or clinics. An electrologist may use the shortwave epilator a maximum of about six hours per day. The American Electrolysis Association, located in Chicago, Illinois, has approximately 1,700 members. We requested and obtained this association's membership list to identify the operators of shortwave epilators. This list and the FCC registration files could be used to construct a study population.

However, we do not recommend electrologists as a study population. Although a total population of approximately 1,700 to 2,000 operators of shortwave epilators does exist, electrolysis centers or clinics typically have only one full-time electrologist and one shortwave epilator. Also, most electrologists do not use the equipment every day. No available data suggest that shortwave epilators are emitting stray radiation and potentially exposing operators of these units. Therefore, electrologists are most likely unsuitable for study, since the population is too difficult to locate, and the exposure data and work environment cannot be standardized.

This chapter has traced the expansion of information about all elements in the study universe of medical and therapeutic applications. Through literature searching and contacting professional organizations, medical experts, schools, and equipment manufacturers, we verified the applications that involve the use of RFR. This resulted in narrowing the study universe. Additional information described the RF devices used and their operation. By

Table 11. SURVEY OF ELECTROLYSIS CENTERS AND CLINICS

Centers/Clinics	Number of Full-time Electrologists	Number and Type of Shortwave Epilators
Accredited Electrolysis of Northern Virginia	1	1 Instatron
Garfinkel Electrolysis Associates	3	1 Proteus 1 Fischer
ARCO Electrolysis	1	1 Instatron (SS 69)
The Electrolysis Clinic	2	3 Instatron (SS 69)
Christine Valmy of Arlington	1	1 Kree
Electrolysis Center of South Arlington	1	1 Instatron
Garfinkels	1	1 Sudonna

finding out where these devices are used, we identified people who could be exposed to RFR. Certain applications were eliminated because use of RF radiation is so limited that feasible study populations could not be identified. The study universe was finally narrowed to three applications. The analysis of the information on these applications led to the identification of one possible study population, diathermy unit operators. This population is characterized in detail in chapter 8.

CHAPTER 7

COMMUNICATIONS AND NAVIGATION APPLICATIONS

This chapter examines the research progression from the study universes of communications and navigation applications of radiofrequency radiation (RFR) to the identification of possible study populations. RF energy is today the main component of most communications and navigation technologies.

Literature searching and information gathering revealed the following potential study universes of communications and navigation applications:

Communications
- AM/FM broadcasting
- Television broadcasting
- Point-to-point telephones
- Satellite broadcasting
- Two-way radios
- Walkie-talkies
- Video display terminals

Navigation
- Aircraft and marine radar (civilian and military)
- Avionics
- Landing systems.

We acquired information about these applications by contacting the appropriate professional associations, trade unions, and occupational organizations. In addition, we contacted experts in the field, relevant Government agencies, manufacturers, and factories. Appendix C lists the sources contacted. We verified the use of RFR radiation in all the communications and navigation applications. The expansion of our information base is described in section 7.1.1 for communications technologies and in section 7.2.1 for navigation.

In this instance, the expansion of the information base did not enable us to narrow significantly the study universe. Therefore, we had to obtain more specific information for each application to try to identify populations that might be exposed to RFR. Using information received from various technical experts, we eliminated marine navigation from the study universe. Radar devices are located so high on ships that personnel exposure is very unlikely. In addition, Elliot Postow and Thomas Rozzell of the Navy advised us to exclude military populations as a potential study group. The National Institute for Occupational Safety and Health (NIOSH) investigated the possibility of using a military population for a RF epidemiology study and found that the existing military records were not adequate to formulate a study population (Matusow, 1980). In addition, many military applications of RF energy involve classified national security information.

The analysis of the information acquired led to the identification of the following possible study populations associated with the applications of the original study universe:

Communications

- Long-line workers
- Tower climbers
- Radio operators
- School children near broadcasting towers
- Users of two-way radios and walkie-talkies

Navigation

- Air traffic controllers
- Radar technicians
- Aircraft mechanics
- Police radar users.

These populations are described in terms of size and of available personnel and exposure data in sections 7.1.2 (communications) and 7.2.2 (navigation). Information obtained through research permitted the elimination of several potential study populations, because the possibility of exposure is unlikely or the populations could not be adequately characterized.

7.1 COMMUNICATIONS TECHNOLOGIES

This section describes the RF applications in communications technologies that constituted the study universe, and the research conducted on the potentially exposed populations.

7.1.1 Evolution of the Study Universe

By searching standard reference books, Government publications, and scientific articles, we identified the applications of RFR in communications technologies that constituted the original study universe. Almost all applications of RF energy in communications technologies fall within the frequency range of 500 KHz to 10 GHz. To progress beyond this list, we contacted professional associations, trade unions, occupational organizations, and Government agencies to inquire about these applications.

AM broadcasting stations operate on frequencies of .535 to 1.6 MHz. AM signals radiate over a large area, with the whole broadcasting tower acting as the antenna. As of 1978, there were 4,497 licensed, commercial AM stations broadcasting in the United States (Electronic Industries Association, 1979).

FM broadcasting stations operate on frequencies of 88 to 108 MHz. FM antennas, mounted on high towers, radiate signals over a broadcast range of approximately 30 miles. As of 1978, there were 3,005 licensed, commercial FM broadcasting stations in the United States (Electronic Industries Association, 1979).

Television broadcasting stations operate on frequencies of 54 to 216 MHz (VHF) and 470 to 806 MHz (UHF). TV antennas are mounted high on towers and radiate signals over a large area. As of 1978, there were 724 licensed, commercial TV broadcasting stations (Electronic Industries Association, 1979).

Point-to-point telephone communications or microwave radio relay systems are used for long distance communication. These systems operate on frequencies of four to six GHz. Point-to-point microwave stations are generally located 30 miles apart. A fully loaded station has between 8 to 12 antennas on its tower. The antennas are generally located at least 200 feet above the ground and have nondirectional transmitting patterns, concentrated over a small cross-sectional area. Satellite communications operate like point-to-point microwave communications, except the stations and antennas are much larger. As of 1978, there were seven American satellites in orbit, excluding Defense Department satellites (Electronic Industries Association, 1979).

Mobile radios include both two-way radios and walkie-talkies. Two-way radios operate on frequencies of 3 to 900 MHz. Walkie-talkies operate on about ten different frequencies, but the frequencies used most often by Government agencies are between 68 to 420 MHz. In 1978, there were about 51,106,000 mobile transmitters (two-way and walkie-talkies) in the United States. The majority of the mobile transmitters (45,500,000) are used for personal purposes. Public safety activities, including fire, forestry, and police services, use about 1,100,000 mobile transmitters and constitute one of the largest user populations. Mobile transmitters are also used by providers of land transportation, industrial, marine, and disaster services (Electronic Industries Association, 1979).

7.1.2 Progression from Applications to Study Populations

By expanding our information base, we verified that RFR is used in all applications that constituted the study universe, except one, as described below. The next step was to determine the possible populations exposed to these applications. Many of the associations contacted supplied general information on the application of RF technology in communications, but were unable to suggest any possible populations exposed. The following possible study populations were identified by the associations and experts listed under each population:

- Long-line workers
  - Communications Workers of America

- Tower climbers
  - Energy Telecommunications Electrical Association
  - American Radio Association
  - National Association of Broadcast Employees and Technicians
  - Robert Curtis - OSHA
  - Elliot Postow - Naval Research Development Command
  - Robert Cleveland - FCC
  - Richard Tell - EPA

- Video display terminal users
  - Communications Workers of America

- Radio operators
  - American Radio Association
  - Community Antenna Association

- School children
  - Multiple Broadcast Antenna Commission
  - Richard Tell - EPA

- Users of two-way radios and walkie-talkies
  - Thomas Rozzell - Navy.

We gathered information from manufacturers and technical engineering companies and acknowledged experts in the communications field on the possibility of using the six populations in an epidemiological study of the health effects of exposure to RFR. Each of these populations is discussed below in relation to size and availability of necessary data.

Long-line Workers

Long-line workers who are employees of AT&T do the maintenance and technical work on all Bell Telephone point-to-point microwave relay towers. Other telephone companies have point-to-point microwave relay towers but do not have a comparable group of technicians. They contract their maintenance and technical work out to tower maintenance companies. Although the long-line workers can be considered tower climbers, we chose to consider them separately because long-line workers work solely on point-to-point systems, which have directional broadcasting patterns. Tower climbers work on towers that have nondirectional broadcasting patterns.

Bell Telephone's microwave relay systems have a transmitting antenna and a receiving antenna located on towers, which are usually about 30 miles apart. The antennas are cornucopia-shaped: the open end is rectangular, four feet across and five to six feet long, and tapers down to a three-inch pipe guide, which runs down the middle of the tower. These antennas are highly directional and only transmit within a three-inch circumference. The name, point-to-point communications, is derived from the fact that the beam of microwave energy is transmitted in a straight line from point A, on the transmitter antenna, to point B, on the receiving antenna.

To determine whether long-line workers could constitute a possible study population, the following associations and experts were contacted:

- Communications Workers of America
- Ronald Peterson - Bell Labs Environmental Group
- George Barnard - Bell Telephone Long-lines Safety Group
- Melanie Klinginsmith - Bell Telephone Public Relations
- Pat Strollo - MCI
- Robert Curtis - OSHA
- Richard Olsen - Navy
- Charles Lomus - Multiple Broadcasting Antenna Commission.

The Communications Workers of America, representing about 85 percent of AT&T's employees, is very interested in the question of long-line worker exposure to RFR. This union is currently looking into the question of identifying a study population within their membership, but it has not made any recommendations.

The Bell Telephone long-line workers are a fixed group of about 200 technicians, based in Kansas City, Missouri, who travel throughout the country maintaining the microwave relay stations. Occasionally, Bell Telephone contracts are awarded to a private firm in White Plains, New York, which employs 100 workers. Bell Telephone would not disclose the name of the White Plains firm.

All of the sources contacted, including Robert Curtis of OSHA, stated that long-line workers have little opportunity to be exposed to RFR, but that when exposure does occur, it is at levels greatly exceeding the 10 mW/cm^2 recommended limit. The opportunity for expsoure is slight since the long-line worker would have to stand directly in front of the center of the antenna, where the radiating beam is located. Most of the maintenance work on the antennas is done from the back, so there is very little opportunity for the worker to be exposed. In addition, the receiving antenna is always turned off when maintenance work is performed, so as not to cause static in the phone transmission. In spite of these limitations, exposures to high intensity RFR can occur. These exposures would be relatively few in number, however, and not adequately documented or reported.

The Occupational Safety and Health Administration, the Environmental Protection Agency, and Bell Telephone have done radiation surveys on microwave relay systems, which have shown that any radiation that might be encountered by a long-line worker is extremely low level, well below the American National Standards Institute (ANSI) guidelines. Power densities in the axis of the main beam, which is typically 200 feet above ground, are about 1,000 mW/cm^2. The power density falls off rapidly with distance from the beam axis. At ground level, maximum calculated values would be less than 1 mW/cm^2, and measured values were 1/10 to 1/100 of this, that is, 0.1 to 0.01 mW/cm^2 (Janes, 1979).

Long-line workers are not recommended as a possible study population. A population sample size of 100 to 200 people is not adequate for an epidemiological study of the health effects of exposure to RF radiation. More importantly, the potential for long-line worker exposure to RFR is too limited to permit the study of chronic exposure.

Tower Climbers

Tower climbers who work on broadcasting towers include both general maintenance personnel and technical trouble-shooters. The unskilled maintenance workers are involved in the building and general maintenance of the tower. Technical trouble-shooters are technical engineers who adjust the antenna system.

Seven of the sources contacted suggested considering tower climbers as a possible study population. Most sources agreed that there is a potential for exposure in tower maintenance. The following tower erection and maintenance companies, antenna manufacturers, broadcasting engineers, acknowledged experts, and Federal Communications Commission (FCC) officials were contacted to determine whether tower climbers could be a feasible study population:

Stainless, Inc.
Kline Iron and Steel
Southern Towers
National Steel Erectors
Tower Systems
Nudd Corp.
Antenna, Inc.
RCA Service Corp.
Bel-Tronics
Chu Associates
Com Associates
CONRAC
Mutual Broadcasting Co.
Charles Lomus - Multiple Broadcasting Antenna Commission
Elliot Postow - Naval Research Development Commmand
Stephen Lynn - FCC FM Broadcasting, Engineering Dept.
Unarco-Rohn
Brooks Erection
Robinson Towers
Ellis Towers
Hamilton Erection
Antenna Research Association
AEL, Inc.
Anixter-Mark
Chisholm-Ryder Co.
Cincinnati Electric
Compagne Generale de Telecommunication
Micab
National Association of Broadcasters
Bob Cleveland and Vernon Wilson - FCC
Robert Curtis - OSHA
Richard Tell and David Janes - EPA
Jules Cohen - Consulting Engineer

Tower erection and maintenance companies are very small operations: the average number of employees is usually between six and ten. Tower climbers are transient iron workers or painters, who may work on a number of other construction or maintenance jobs that do not involve exposure to RF radiation. Each company usually has one or two workers who have been with the company for seven to ten years, while the rest of the workers are employed on a monthly or yearly basis.

Tower climbers may be exposed to local fields near the antenna elements that are above the 40,000 V/m^2 value recommended by the ANSI (Janes, 1979). Robert Curtis of OSHA estimated that radiation levels could be as high as 1,000 mW/cm^2 in the direct path of the broadcasting antenna beam.

To create an adequate sized study population, tower climber populations would have to be aggregated nationally. Maintenance tower climbers would not have standardized health or work histories available, because most tower maintenance and erection companies do not keep such records for these transient workers. In addition, exposures are isolated and, generally, the exposure levels are likely to be very high.

Technical trouble-shooters are electrical engineers employed by broadcasting stations. Each broadcasting station has one or two electrical engineers on staff and may hire others on contract. Companies that manufacture broadcasting antennas do not often send their trouble-shooters out into the field. Whenever possible, they prefer to have their technical assistance personnel work with broadcasting station electrical engineers over the phone.

Broadcasting antennas require very little technical maintenance. Technical trouble-shooters usually only make an adjustment when the antenna has been damaged by natural forces such as high winds or lightning. Therefore, the technical trouble-shooter does not climb an antenna tower regularly.

Although technical trouble-shooters also would not have standardized medical or work histories, the available information would be more extensive than for tower climbers because broadcasting station employees tend to stay for a long period of time.

We do not recommend tower climbers as a possible study population. We recognize that tower climbers can be exposed to RFR; however, they are not an appropriate study population for an epidemiological study because exposures are isolated, and standardized personnel and medical data are not available.

Video Display Terminal Users

The Communications Workers of America is a union representing employees, such as airline ticket personnel and newspaper reporters, who use video display terminals. These terminals emit x-rays, and communications workers are concerned that the terminals may also emit RFR, which could cause cataracts.

According to a recent BRH study (BRH, 1981), video display terminals do produce some RFR. The primary source of RFR is in the horizontal deflection system and its associated high voltage transformer. The pulsating high voltage in these systems creates the RF fields present around video display terminals. However, BRH concluded that the emission values from video display terminals were within existing State, Federal, and international guidelines. The RFR emitted from a video display terminal is comparable to the amount emitted from a television set. We do not recommend video display terminal operators as a study population because the exposure levels are exceedingly low and the operators are also exposed to low levels of ionizing radiation from the terminals.

Radio Operators

Radio operators maintain the broadcasting equipment, such as modulation monitors, indicating instruments, harmonic filters, and transmission lines, in the station. Radio operators are licensed by the FCC. Every station must have one first-class radiotelephone operator available at all times.

The American Radio Association and the Community Antenna Association suggested considering radio operators as a possible study population. The following experts in the broadcasting field were contacted to determine whether radio operators could constitute a possible study population:

- Robert Curtis - OSHA
- Stephen Lynn - Broadcasting Bureau, FCC
- Richard Olsen - Navy
- Charles Lomus - Multiple Broadcasting Antenna Commission
- Vernon Wilson - Field Operations Bureau, FCC
- Chris Payne - National Association of Broadcasters
- Mutual Broadcasting Co.

All of the experts contacted agreed that radio operators are not exposed to RF radiation. A radio operator could only be exposed to RFR if he or she climbed a tower to make an antenna adjustment. Radio operators work with equipment that runs on high power electrical energy, not RF energy. Based upon the negative responses from these experts, we did not contact any broadcasting stations, and we do not recommend radio operators as a possible study population.

School Populations Located Near Broadcasting Towers

Richard Tell of the Environmental Protection Agency's Office of Radiation Programs and the Multiple Broadcasting Antenna Commission suggested using the children in schools located near broadcasting towers as a possible study population. The following education and state health officials, the FCC, and a number of experts in the broadcasting field were contacted to determine whether school children could constitute a feasible study population:

- Richard Tell - EPA
- Stephen Lynn and Robert Greenberg - FCC Broadcasting
- Priscilla Mulls - FCC - Antenna Survey branch
- George Berzins - Voice of America
- James Shipman - FAA - Obstruction of Airspace
- Jules Cohen - Consulting Engineer
- Multiple Broadcasting Antenna Commission
- Michael Gregg - Center for Disease Control
- Gracen Miller - Virginia State Health Department
- Polly Roberts and Irene Addo - Maryland State Health Department
- George Hammill, Frank Elliot, and Sylvia Auton - Fairfax County School System
- Imelda Hodge - National Center for Education Statistics, Department of Education
- Martha Willes and Mordecai Lawson - FEMA
- U. S. Geological Survey - Mapping Department
- Elliott Postow - Navy.

Seven of the sources contacted felt that a school population would constitute a good study population for an epidemiological study of the health effects of exposure to low-level RF radiation. Based on this response and the information gathered from school and health departments, we recommend a school population as a feasible study population. This population is discussed in detail in chapter 8.

Police and Security Officers

Thomas Rozzell of the Navy suggested security officers who use two-way radios, walkie-talkies, and radar as a possible study population. The following police departments and security departments of national agencies were contacted to determine whether security personnel could constitute a feasible study population:

- Maryland State Police
- Joe McDell, William Keefer - Fairfax County Police
- R. H. Wimmer - Virginia State Police
- Paul Donahue - Delaware State Police
- Quinton Lawson - GSA
- Ray Bell - Capital Police
- Al Zitel - Park Service
- Ronald Colaprepe - Smithsonian Institution
- Laurie Anderson - Secret Service
- Damian Romanelli - Library of Congress.

All of the sources stated that they regularly used microwave equipment; however, they do not all use the same type of equipment. Police departments generally use radar and two-way radios, while security personnel use walkie-talkies and occasionally two-way radios. Therefore, although they must be considered separately, both populations, police officers and security personnel, are feasible study populations.

7.2 NAVIGATION TECHNOLOGIES

This section describes the applications of RF radiation in navigation that constituted the study universe and the research progression to possibly exposed populations. Since radar was developed during World War II, all high technology navigation systems have used RF energy.

7.2.1 Evolution of the Study Universe

Radar technology is based on the reflection of pulsed microwaves by electrical conductors. Radar is used for marine and aviation navigation. The Federal Aviation Administration (FAA) is the largest civilian user of radar for navigation. By searching standard reference books, Government publications, and scientific articles, we identified the applications of RFR in navigation technologies that constituted the study universe. We contacted professional associations, trade unions, and Government agencies to find out about these applications.

Aircraft radar is located in the nose of the aircraft and is often called weather-tracking radar. This type of radar uses an antenna that continuously rotates 360 degrees or oscillates in a sector scan. Most aircraft radar operates on a frequency of 9.375 GHz. The pulse-peak power on most of the aircraft radar ranges from 40 to 75 KW. The National Bureau of Standards surveyed field intensities from aircraft radar and found that because of shielding, radiation within the cockpit was negligible. The highest level of radiation measured was 0.101 mW/cm^2 (Larsen and Shafer 1977).

Ground radar systems are called airport surveillance radar (ASR), the highest power radar unit in operation at most FAA installations (Larsen and Shafer 1977). A higher powered radar system, known as the air route surveillance system (ARSR), monitors regional air traffic.

Airport surveillance radar operates on a frequency band of 2.7 to 2.9 GHz. Air route surveillance radar operates on a frequency band of 1.25 to 1.35 GHz. These systems have highly directional antennas that illuminate only a small volume of space at any time (Larsen and Shafer 1977).

Instrument landing systems consist of runway localizer antennas in the 100 MHz band and glide-slope transmissions in the 300 MHz band. The conventional instrument landing systems in use today depend on modulated signals for guidance. The localizer provides horizontal (lateral) guidance and the glide slope provides vertical (descent angle) guidance for aircraft approaching a runway (Larsen and Shafer 1977).

The microwave landing system is a new system currently being tested by the FAA. This system operates on the Ku frequency band of 15.4 to 15.7 GHz or in the C frequency band of 5 to 5.25 GHz. It is an improvement over the conventional instrument landing systems in use today, because it has more frequency channels and eliminates interference caused by RF ground reflections. This system is expected to replace the old instrument landing system in the near future.

7.2.2 Progression from Applications to Study Populations

The information gathered verified the use of RFR in all the applications of the study universe. To identify populations associated with these applications, we contacted several trade unions and professional associations. Many of these associations supplied general information on the application of RF technology in navigation, but were unable to suggest any possible populations. The list below gives the possible study populations identified by the associations and experts listed under each one:

- Air traffic controllers
  - National Association of Air Traffic Specialists
  - Air Traffic Control Association

- Aircraft mechanics
  - International Association of Machinists and Aerospace Workers

- Video display terminal users
  - International Association of Machinists and Aerospace Workers

- Police radar users
  - Thomas Rozzell - Navy

- Radar technicians
  - National Association of Air Traffic Specialists
  - International Association of Machinists and Aerospace Workers
  - Air Traffic Control Association
  - General Aviation Manufacturers Association
  - Commuter Airline Association of America
  - Aviation Maintenance Foundation
  - Aeronautical Navigator Association
  - Professional Airway System Specialist
  - Federal Aviation Science and Technology Association
  - Steven Fewell, Robert Thompson - FAA.

We gathered information on occupational exposure from manufacturers, the FAA, which employs the majority of civilian radar technicians and air traffic controllers, and acknowledged experts in the navigation field. All five groups are discussed below.

Air Traffic Controllers

Air traffic controllers are "responsible for the safe, orderly and expeditious flow of air traffic." They are responsible for "assuring vertical, longitudinal, or lateral separation of aircraft traversing [their] sector, while.... providing pilots with instructions or information as to when to climb, descend or turn to accomplish a particular objective" (FAA 1973).

The National Association of Air Traffic Specialists and the Air Traffic Control Association, which represent air traffic controllers, expressed concern about exposure to RFR. The FAA, the largest civilian employer of air traffic controllers, and the following experts in the navigation field were contacted to determine whether air traffic controllers could constitute a feasible study population:

- Steven Fewell, Robert Thompson, Joseph Sirkus - Occupational Safety, FAA

- Paul Rich - Navigation Dept., FAA

- Elliot Postow, Thomas Rozzell, Paul Tyler - Navy

- Robert Curtis - OSHA.

All these sources agreed that air traffic controllers are not exposed to RFR from radar. They cannot be exposed to RFR from radar because the radar antennas are located in remote areas, sometimes as far as 20 to 30 miles away from the air traffic control tower. The tracking data are transmitted from the remote antenna to the air traffic control tower by electrical impulse. However, air traffic controllers use video display terminals and therefore would be exposed to low levels of RFR emitted from these terminals. As indicated earlier, in the communications section, users of these terminals would not constitute a potential study group.

Radar operators perform the same function as air traffic controllers, but in marine navigation. Radar operators were not suggested as a possible study group by any of the sources we contacted. They would not be a feasible study population for the same reasons that apply to air traffic controllers.

Aircraft Mechanics

Aircraft mechanics are the technicians who maintain and inspect aircraft. However, for our purposes, technicians who work on radar will be considered separately as radar technicians.

The International Association of Machinists and Aerospace Workers, which represents a number of aircraft mechanics unions, suggested investigating the possibility of using aircraft mechanics as a study population. The following experts in the navigation field were contacted to determine whether aircraft mechanics could constitute a feasible study population:

- Steven Fewell, Robert Thompson, Joseph Sirkus - Occupational Safety, FAA
- Paul Rich - Navigation Dept., FAA
- Robert Curtis - OSHA.

All of the sources agreed that while aircraft mechanics may be exposed to ambient levels of RF radiation, they are not exposed chronically to any direct source of RFR. Aircraft mechanics are much more likely to be exposed to ionizing radiation, because they use x-ray equipment to check the aircraft for structural cracks. Aircraft mechanics are not exposed to radar and weather-tracking equipment in the nose of the aircraft, because this equipment does not operate when the aircraft is on the ground. They are not exposed to the airport radar, because it is generally located some distance from the airport. They are exposed to radiation from the microwave landing system.

We do not recommend using aircraft mechanics as a study population, because they are not directly exposed to RF radiation from radar and they are chronically exposed to ionizing radiation.

Video Display Terminals

As discussed earlier in the communications section, video display terminal users are not recommended as a possible study population.

Police Radar

The traffic and highway departments of each police department use low power, continuous wave radar to track the speed of vehicles. The police departments listed below were contacted to determine whether police who use radar could constitute a possible study population:

- Maryland State Police
- Fairfax County Police
- Fairfax County Police Motor Squad
- Virginia State Police
- Delaware State Police.

From the information obtained, we concluded that exposure to police radar alone would not be sufficient exposure to warrant recommending police as a study population. However, police also use two-way radios and walkie-talkies which emit RFR. The fact that police use all three pieces of equipment does enhance the possibility of studying a police population for epidemiological research into chronic low-level exposure to RFR. Therefore, this population is discussed in greater detail in chapter 8.

Radar Technicians

Radar technicians are the electronics technicians who maintain radar systems such as the VOR (VHF omni directional range) and TACAN (Tactical Airborne Navigation) systems. A radar technician "determines whether the assigned system(s) are operating within specified tolerances and ... performs the full range of periodic and corrective maintenance including the isolation and correction of causes of malfunctioning and the repair and restoration of service in the event of systems failure" (FAA 1973).

All but one of the sources contacted suggested investigating the possibility of using radar technicians as a study population. Therefore, the following radar manufacturers, unions that represent radar technicians, and the FAA, which employs the majority of civilian radar technicians, were contacted:

- Steven Fewell, Robert Thompson, Joseph Sirkus - Occupational Health, FAA

- Chet Lament - Labor Relations, FAA

- Connie Triplet, Jan Marshall, Frieda Johnson, Richard Cullen - Personnel, FAA

- Inez Weaver, Virginia Hicks - Medical Records, FAA

- Howard Johannssen - Professional Airwave System Specialist

- Stanley Lyman - Federal Aviation Science and Technology Association

- Cincinnati Electronics

- AEL, Inc.

- Elliot Postow, Paul Tyler, Richard Olsen, Thomas Rozzell - Navy

- Robert Curtis - OSHA

- Terry Leet - NIOSH
- Robert Cleveland - FCC.

All of the technical experts contacted agreed that radar technicians are the most feasible study population in the navigation field. However, most of them admitted that radar technicians would not be an ideal study population, because exposure to RFR is intermittent and under proper conditions should not occur at all. We have included radar technicians in our list of possible study populations because of the expressed interest in such a study.

This chapter has traced the expansion of information about the applications of RFR in communications and navigation that constituted our two study universes. Through literature searching and contacting various organizations, Government agencies, manufacturers, and experts, we described these applications. By additional expansion of the information base, we identified population groups associated with these applications and potentially exposed to RF radiation. Certain populations were eliminated from consideration because they do not possess the specified characteristics of an epidemiological study population. The analysis of the information acquired led to the identification of three possible study populations: school children near broadcasting towers, police and security officers, and radar technicians. These populations are characterized in detail in chapter 8.

CHAPTER 8

POPULATION CHARACTERIZATION

This chapter discusses populations identified as potential groups for the study of the possible health effects associated with exposure to radiofrequency radiation (RFR). The technical data and background information related to the applications that led to the identification of the populations have been presented in chapters 5, 6, and 7. As described in the following sections, each recommended study group satisfies most of the criteria we identified as necessary for a group to serve as a suitable population for an epidemiological study:

- Minimum sample size of 200
- Availability of exposure data
    - Actual use of an RF-emitting device
    - Documentation of brand of equipment used
    - Documented cases of type of device leaking RFR
    - Potential for measuring leakage
    - Documentation of actual measurements performed at various facilities
- Availability of Personal data
    - Occupational/personnel records
    - Medical records or other health status indicators: clinics, physician, insurance, or health maintenance organization
- Availability of suitable control group
- Indication of cooperation in potential study.

Both the advantages and disadvantages of each study group are included in each discussion.

8.1 INDUSTRIAL AND COMMERCIAL POPULATIONS

According to the criteria listed above, two occupational groups within the industrial and commercial populations considered would be suitable groups for the study of the health effects of exposure to radiofrequency radiation: operators of RF heat sealing devices and operators of HF steel tube welding equipment.

8.1.1 RF Heat Sealer Operators

The advantages and disadvantages of using operators of RF plastic heat sealers as a study population are summarized in table 12. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

Table 12. SUMMARY OF EVALUATION OF RF HEAT SEALER OPERATORS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - RF Heat Sealer	Commonly used Long-term use Similar operating procedures	
Population size	20,000 RF units 30-40,000 operators Men and women operators	Only 5-15 operators/shop
Personnel data	Available: - Company records - Medical insurance - Personal interviews - Personal physicians' records	Records difficult to retrieve from non-union shop Records not standardized in form or content Employee permission required to get private physician records
Extent of exposure	Leakage documented Exposure levels monitored Possible to reconstruct exposures	No personal dosimetry
Control groups	Non-operators available	Ensure adequate size Ensure no exposure to RF

When we contacted manufacturers of RF heat sealers and plastic factories that use RF heat sealing equipment, we obtained information on:

- The type of equipment they manufacture or use
- The number of persons they employ to manufacture the RF heat sealers or as RF operators
- The availability of personnel records
- The surveying of the RF heat sealers for radiation leakage.

Data were also obtained on the availability of other employees who could be used as a control population. Their cooperation in any future study or survey was also requested, but not all factories indicated that they would cooperate. Table 13 lists the different plastics factories that were contacted and the type of information each provided.

As described in chapter 5, RF heat sealing equipment must be registered with the Federal Communications Commission (FCC). Arthur Wall of the Licensing and Surveillance Branch of the FCC agreed that the registration forms would be useful to us and stated that the FCC branch had received a similar request from the Surveillance, Hazards Evaluation, and Field Study (DSHEFS) group of NIOSH (Cincinnati). Wall informed us that the FCC had recently relinquished many of the RF registration forms to NIOSH to aid in their industrial survey of occupational exposure to RFR generated by RF heat sealing devices. We had already learned from Dr. Charles Liddle of the Environmental Protection Agency and Robert Curtis of the Occupational Safety and Health Administration that Terry Leet of the DSHEFS group of NIOSH was involved in an investigation of RF heat sealer operators. This study is addressed at the end of this discussion.

About 20,000 RF heat sealers are currently being used by about 30,000 to 40,000 persons, with most workers in the plastic fabrication industry (NIOSH/OSHA 1979). Most factories employ between 5 and 15 persons to operate the RF heat sealing devices. Therefore, we would need to identify as many as 40 factories to attain a population group of 200, the size deemed adequate for study.

The available data on the use of the devices indicate that many of these people operate RF heat sealers on a full-time basis, eight hours per day, 50 weeks per year. Most of the plastics factories that we contacted reported that the operators of RF sealers tend to remain at their jobs for at least several years. The nature of the work requires the operators to sit or stand quite close to the electrodes that generate the RF radiation. Therefore, if RF radiation is "leaking" from the RF sealer, the operators may be continually exposed in the near-field for an extended time. In addition, RF heat sealers are usually located in one work area of a factory and tend to be only three or four feet from each other. Consequently, an operator may receive near-field exposure from his or her own RF device and far-field exposure from other RF heat sealers nearby. This overlap of exposure would need to be considered when evaluating the extent of exposure to RF heat sealer operators.

Table 13. SURVEY OF MANUFACTURERS AND USERS OF RF HEAT SEALERS

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Solidyne Corp. Bay Shore, NY	5-8	Manufacture RF heat seal devices	Some	Known	No	Yes
Batson Machinery Greenville, NC	3	Manufacture small RF heat sealers	No	Minimal	No	
Blair Plastics Chicago, IL	30-35	Use 30 RF heat sealers	Non-union, so available individually	Yes	Probable	Yes
Classic Prods. Beltsville, MD	70-80	Use 55 RF heat sealers	Non-union, so available individually	No	No	Yes
Allegany Plastics Coraopolis, PA		Use only 1 RF heat sealer (part-time)	No	No	No	No
Fidelity Plastics Avon, PA	Not Available	Not Available				

(Continued)

Table 13. (Continued)

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Fabrico Chicago, IL	75 total, 30-35 operators	50 RF sealers	Unionized	Yes (NIOSH)	Yes	Yes
Marlo Plastics Brooklyn, NY	10-15 operators	Use 10 RF plastic heat seal devices	Non-union	None	Probable	Non-operators
Best Seal Corp, New York, NY	10-15	RF heat sealers	Non-union	None	No	Non-operators
Plastics Services Erwin, TN	5-10	Use a few RF heat sealers	Non-union	None	Yes	Non-operators
Tracies Co. Holyoke, MA	30-40	Use 30 RF heat sealers	Non-union	Minimal	Probable	Non-operators
Meda Plast. Philadelphia, PA	8-10	Use 8 RF heat sealers	Non-union	None	No	
Abar Plastics Beltsville, MD		Do not use RF sealers				

(Continued)

Table 13. (Continued)

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Pittcon Ind. Cheverly, MD		Do not use RF heat sealers				
Leelyn Plastic Springdale, AK	20 RF operators	RF heat sealers	Very little - no company clinic or physician. Only health insurance for employees.	None	Yes	About 80 non-operators
Beltsville Plastics Beltsville, MD		Use RF heat sealers			No	
Day Plastics Hoboken, NJ	1 RF operator (part-time)	Use 1 RF device				
Apex Plastics Dania, FL	70-80 operators	Use RF heat sealers	Very little-only health insurance benefits	Little	Yes	Office Personnel
Arrow Plastics Dorchester, MA	25 employees 10-15 operators (part-time)	Use 10 RF heat sealers	Minimal	None	Yes	Non-operators

(Continued)

Table 13. (Continued)

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Command Plastics Akron, OH	50 employees, 10-15 operators (part-time)	Use 10 RF sealers	Minimal	Checked every year by manufacturer	Possibly	Non-operators
Polo Plastics Topeka, KS	175 total, 30 operators	Use 30 RF sealers	Minimal	Some	Yes	Non-operators
Petra Mfg. Chicago, IL	30 total 10 operators	Use 10 RF sealers	Minimal, although recently unionized	None	Yes	Non-operators

These working conditions were observed during a site visit to a vinyl factory that operated 55 RF heat sealers and employed a total of 85 workers. The shop was not unionized, and many of the RF operators were women between the ages of 18 and 40. Because the wages are relatively high for this type of work, the employees tend to remain on the job for several years. At least one worker is required to operate each RF device, although several machines are quite large and require three to seven operators. The devices have never been monitored, and the plant manager did not know whether the RF devices exposed the operators to radiation levels greater than 10 mW/cm^2, the OSHA safety limit. He stated that he had been working near RF heat sealers for years and that he had no health problems, nor was he aware that any of his employees had ever experienced health effects related to exposure to RF radiation.

Nevertheless, the potential for exposure to RF radiation does exist for persons who operate RF heat sealers. These sealers are infrequently monitored for stray radiation, and since many of these devices can be operated for 10 to 20 years before they are replaced, an operator may unknowingly be exposed to excessively high levels of RF radiation. Industrial surveys conducted by Stuchly and others (1980a) and Conover and others (1978) indicated that some operators of RF heat sealers are exposed to stray RF radiation exceeding 10 mW/cm^2. Because operator exposure occurs in the near-field region, these power density measurements actually refer to E field exposures greater than 200 V/m and H field exposures exceeding 0.5 A/m. Since this level of exposure can occur whenever the RF sealer is in operation, cumulative exposures received by operators can be great, since they work full-time, year after year. Based on the total number of people and the potential for exposure, RF heat sealer operators represent an excellent population for the study of health effects associated with chronic, repeated exposure to levels of RF radiation that often exceed the OSHA safety standard.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of past employment responsibilities is necessary to determine if operators of RF heat sealing devices could have been exposed to microwave/RF radiation in the past. Personnel and medical records would be needed for both the RF heat sealer operators and the employees serving as controls.

Acquiring complete employment and medical data for persons working in plastics factories is unlikely. Most of these factories are individually owned and not unionized. As a result, employment and personnel records are not standardized and some may be more complete than others. In addition, the types of personnel data available would differ from factory to factory because of different application forms and employment procedures.

Similarly, the likelihood of acquiring complete medical records for these employees is small, since the non-unionized factories do not have company health clinics where the employees go for routine medical care. Employees are sent to clinics, typically a nearby community clinic, only if an accident or injury occurs while the worker is on the job. Worker's compensation and hospitalization insurance provided by the employer cover most other work-related illnesses or medical problems for which the employees consult their personal physicians. Therefore, all health data and medical histories would need to be retrieved through the employees' personal physicians. Since different physicians and group health insurance plans use different record-keeping procedures and medical forms, the data retrieved from these sources would not be standardized to any extent. Despite these problems, some medical data could probably be retrieved for most of the individuals who work in vinyl factories. Although the data are not consistent, they would help in establishing the medical histories of persons included in the study population.

The availability of an appropriate control group must also be considered in evaluating the suitability of RF heat sealer operators as a study population. Because these individuals work in vinyl factories, they are certainly exposed to fumes and gases released from vinyl plastic when it is heated. Therefore, it would be difficult to attribute any adverse health effects solely to exposure to RFR. To compensate for this factor, a control group is necessary and available: persons who work in plastic factories, but do not use or operate RF heating equipment. These persons might include office help, secretaries, foremen and supervisors, and janitors and maintenance personnel. On the average, the factories we contacted employed an office staff of about two persons, two or three foremen or supervisors, and two or three persons on the janitorial staff. The plastics factory that we visited had about 20 employees who never used or operated any type of RF device. The individuals work in the same environment as the RF heat sealer operators, but are not exposed to RFR. The possibility of using these individuals as controls could be reviewed by qualified epidemiologists or biostatisticians.

As mentioned earlier, we learned that NIOSH is conducting an industrial survey on occupational exposure to RFR generated by RF heat sealing devices. We recommend that other interested agencies or groups should work with NIOSH to obtain data for the initial identification of the study population. Terry Leet stated that NIOSH is planning to investigate the incidence of fetal mortality and morbidity in infants of women who, while pregnant, operated RF plastic heat sealers. NIOSH is currently identifying plastics factories to obtain a study population size of between 160 and 250 women who operated RF heat sealing devices during their pregnancies. About 500 women who do not work with RF devices will be selected as controls. NIOSH personnel will conduct industrial hygiene surveys of the shops to determine the extent of worker exposure to RF radiation and other potential hazards. They also plan to obtain medical and pregnancy histories of the women and to administer a reproductive-health effects questionnaire to each subject. This information on the exposed and non-exposed women will provide sufficient data to statistically analyze the incidence of miscarriage and fetal mortality/morbidity. NIOSH plans to complete the identification process by April or May of 1981 and begin the surveys by early summer of 1981.

NIOSH is using the FCC registration forms for RF devices to help identify companies that own more than 20 RF heat sealers. They have already identified many of these companies and have begun contacting them by letter and phone. NIOSH is querying them about their operational procedures, the number of RF heat sealer operators they employ, the number of female operators, and the availability of medical and pregnancy histories of these women. NIOSH has already identified and characterized a small population of women who operate RF heat sealers. However, NIOSH is planning to study only 160 to 250 pregnant women who work in factories with more than 20 RF heat sealing devices. Furthermore, NIOSH is not studying other potential health effects that may result from exposure to RF radiation by limiting the study to the incidence of fetal mortality/morbidity.

We have recently obtained from the FCC the same registration information on RF devices that NIOSH has used to identify companies that owned RF heat sealers. Table 14 is a sample of the type of information included on the FCC forms. The information on the FCC registration forms may not be exact, however. The category on the registration forms concerning industrial heaters includes equipment other than RF heat sealers and, therefore, quite often includes devices other than heat sealers actually in operation in a facility. Despite of this problem, the information could still help identify users of RF heat sealing equipment. However, using this information to identify particular companies that have certain types and numbers of RF devices would duplicate the work already done by NIOSH.

As stated previously, up to about 40,000 persons are employed as operators of RF heat sealers, and probably 10 to 20 percent of these individuals could be identified using the FCC registration data. The NIOSH study could be integrated into this process, so that other agencies or companies working with NIOSH could gain the maximum benefit from all data obtained on the exposure of RF heat sealer operators to RFR.

8.1.2 HF Tube Welder Operators

The overall advantages and disadvantages of using high-frequency (HF) welder operators as a study population are listed in table 15. This information was obtained from many different sources, but most came from steel tube producers that use the HF welding equipment and the trade unions and associations that represent these tube producers. We contacted the major manufacturers of HF welding equipment in the United States, as well as producers of steel tubing that used this equipment. Each establishment was asked to provide information on the type of HF equipment manufactured or used; the number of persons employed to manufacture or operate the HF equipment; the availability of personnel records; and whether the HF welding devices had ever been surveyed for radiation leakage. Information was obtained on the availability of other employees who could serve as a control group. Their cooperation in any future study or survey was also requested, but not all tube producers indicated that they would cooperate. Table 16 lists the steel tube producers that were contacted and the type of information each provided.

By contacting the manufacturers and users of HF welding equipment, we also learned that these devices must be registered with the FCC, like the RF heat sealers. The FCC records would help us identify companies that use HF welding devices.

Manufacturers and users reported that much of the steel and metal tubing produced in the United States is welded with HF devices. Use of HF welding has increased in the last ten years and will continue to increase, because it is an efficient and cost-effective way to manufacture a variety of types of metal tubing. Approximately 1,000 HF welding units are in operation, with about 2,000 to 3,000 individuals involved in operating these machines. These

Table 14. FCC REGISTRATION FILES

COMPANY	DATE	INDUST HEATER	ARC WELD	ULTRA DEV	MEDIC DIA	EPIL	R.F. SIGN	OTHER	TOTAL	BOX NUM
PRECISION HEAT TREATIN CO 259 MONITOR ST BROOKLYN , NY 11222	03/77	001							001	01
KURZ-KASCH INC 711 · HUNTER DR WILMINGTON , OH 45177	03/77	002							002	01
WESTINGHOUSE HANFORD CO 300 AREA RICHLAND , WA 99352	03/77	001							001	01
WESTERN ELEC CO INC 100 CENTRAL AV KEARNY , NJ 07032	03/77	015	07		05			06	033	01
UNIVERSAL WIRE SPRING DIV SHOWALTER DR GEORGETOWN , KY 40324	03/77	001							001	01
BOCK IND OF ELKHART INC 57540 S S R 19 E LKHART , IN 46514	03/77	001							001	01
ALLIED CHEMICAL CORP 1201 CONTINENTAL BV CHARLOTTE , NC 28234	02/77	010							010	01
CLINTON ELEC 6701 CLINTON RD ROCKFORD , IL 61111	03/77	001							001	01
BENDIX CORP SIDNEY , NY 13838	03/77	000							001	01
U S ARMY SUNFLOWER ARMY DESOTO , KS 66018	03/77	004							004	01
SOUTHWEST GREASE & OIL CO 6200 N 16TH ST OMAHA , NB 68110	03/77	002							002	01
SIGMA INSTRUMENTS INC 170 PEARL ST BRAINTREE , MA 02184	03/77	002							002	01
OHIO MEDICAL PRODUCTS PO 1646 TICE ST FORT MYERS , FL 33902	03/77	001							001	01
JOSLYN MFG & SUPPLY CO 1525 LAKE AV WOODSTOCK , IL 60098	03/77	002							002	01

Table 15. SUMMARY EVALUATION OF HF TUBE WELDER OPERATORS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - Tube welders	Commonly used Long-term use Similar operating procedures	Automated
Size of population	3,000 operators Many are union members	Scattered, 2-3 per factory
Personnel data	Available: Individual company records Union records and data - Central source - Standardized formats - Union cooperation Personal interview	Difficult to retrieve if not union
Extent of exposure	Operator remains at job for years Chronic exposure possible	No exposure data available No data on HF leakage HF not monitored
Control Groups	Non-operators Adequate size	

Table 16. SURVEY OF USERS OF HF STEEL TUBE WELDERS

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Armco Tube Co. Middletown, OH	7,000 total employ, <10 HF operators	Use 4-5 HF tube mills	Non-union Minimal data available	None	Yes	Yes
Bethlehem Steel Tubing Baltimore, MD	2 operators	Use only 1 HF welder	Unionized, so records are available		No	Yes
Callier Pipe Co. St. Louis, MO	4-6 operators	Use 3 HF tube mills	Unionized,		Possible	Yes
Higbie (ITT) Tube Co. Rochester, MI	2 operators	Use only 1 HF tube welder	Unionized	None		
Alpha Tube Co. Toledo, OH	2-4 operators	Use 2 HF welders			No	
Donovan Steel Tube Co. Toledo, OH	4 operators	Use 2 HF tube welders	Unionized	None	No	
Republic Tube Co. Cleveland, OH	2 operators & assistants	Use only 1 tube welder	Unionized	None	Possible	Yes

(Continued)

Table 16. (Continued)

Source	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
Babcock & Willcox Tubular Div. Alliance, OH	12 operators & assistants	Use 4 tube mills	Unionized	None	Yes	Yes
Bundy Tubular Steel Hometown, PA		Do not use HF welding as yet				
Copperweld Tubing Shelby, OH	5-10 operators	Use 3 HF tube welders	Unionized	Unsure, but probably none	Written request	Yes
Daily Corp. Montgomeryville, MD	5-10 operators	Use 3 HF tube welders	Unionized	None	No	Yes
Tuesday Ind. Cornwells Heights, MD	6-8 operators	Use 3 HF tube welders	Non-union	None		Yes

operators may be exposed to HF radiation (400 KHz) generated by the welding devices.

A typical tube manufacturer operates one to four tube mills, depending on the size of the factory and the amount of business. The HF welders are an automated part of the production line and usually require only three individuals to operate them, with one of them being the actual HF operator. These individuals, and especially the HF operators, are in a position to receive HF radiation that may leak from the welding unit. These devices are apparently not monitored for leakage, so the operators could unknowingly be exposed to HF radiation.

Operating an HF welder is a full-time job; the machines are often in continuous operation, so worker exposure may occur on a continuous, repeated basis. Long-term exposures are possible since the individuals who operate these devices are highly skilled and must be trained before they are given complete responsibility for the welding process. In addition, most tube-making companies are unionized, and the union may require training and specific occupational responsibilities for individuals who operate HF welding equipment. Therefore, these individuals tend to stay on the job for years and may be chronically exposed to stray radiation during the entire time of their employment.

A site visit was made to a steel tube manufacturer that used three HF welding mills and employed about 80 workers. We found that the operator stands at a control panel about three feet from the HF electrodes, and during the welding process observes the electrodes while they generate HF radiation. The electrodes are not enclosed or shielded in any way. The oscillators and HF generators are housed in large cabinets close to the operator. Since the operator closely watches the welding process the entire time it is in operation, this person is always within several feet of the HF generating equipment. The plant manager reported that the RF generators had never been monitored for leakage in their 15 years of operation. He also stated that he knew of no health problem or concerns that could be associated with exposure to HF radiation in the factory.

Although the potential for exposure to stray HF radiation does exist, data are not available on the level of leakage from HF welders or on the extent of exposure received by operators of these units. Nevertheless, this occupational group should be investigated since they may be chronically exposed to low-level intensities of HF radiation.

In addition, steel tube producers can be recommended because most of those contacted are affiliated with the United Steelworkers of America, which is a central source of information on job classifications, employment records, and, most importantly, complete and standardized medical records. To determine if we could obtain these data, we contacted Paul Hitcho of the Health and Safety Division of the steelworkers union. He informed us that, as part of its medical and compensation benefits, the union maintains health care clinics where members go for treatment of both routine and job-related illnesses, injuries, or accidents. These health care clinics are union-owned and operated, and all maintain the same series of personnel and medical data for each employee for the entire period of membership. The United Steelworkers of

America has offered to make these personnel and medical records available, if they are needed.

This cooperation on the part of the steelworkers union means that although only two or three workers at each factory may be exposed to HF radiation, we can obtain standardized personnel and medical data on workers from many different factories. Contact with individual factories would be necessary only for those that are not unionized by the United Steelworkers of America.

A number of advantages and disadvantages are associated with our recommendation to study operators of HF welding devices. The main disadvantages are the following:

- Only two to three persons per shift per factory may be potentially exposed to stray HF radiation
- HF welding machines are automated and require no manual operation
- No exposure data are available for this occupational group.

These disadvantages are offset by a number of distinct advantages:

- HF operators tend to remain on the job for several years
- The total population numbers between 2,000 and 3,000 individuals
- A control population is readily available and most HF welder operators belong to a single national union, the United Steelworkers of America.

These advantages make it possible to recommend operators of HF welding equipment as a population for the study of health effects that may be associated with exposure to RF radiation.

8.2 MEDICAL AND THERAPIST POPULATIONS

One occupational group within the medical and therapeutic populations identified would serve as a suitable study group for the health effects of exposure to non-ionizing radiation: physical therapists who operate shortwave or microwave diathermy equipment. We were able to acquire data concerning each of the evaluation factors for two groups of physical therapists, those employed by Veterans Administration (VA) hospitals and by accredited rehabilitation facilities.

8.2.1 Physical Therapists in Veterans Administration Hospitals

The advantages and disadvantages of using physical therapists employed by VA hospitals as a study population are summarized in table 17. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

The average number of physical therapists employed by VA hospitals is five. To obtain an adequate population size of 200, therefore, we would need to identify more than 40 hospitals.

We obtained a list of the 172 VA hospitals in the U.S. and contacted 20 to determine how many physical therapists are employed and how much the diathermy units are used. Table 18 summarizes the information obtained. The staffs ranged from one to 11 physical therapists. The hospitals surveyed had from 0 to 5 diathermy units each, with shortwave units outnumbering microwave units by 26 to 15. Most VA hospital physical therapy departments that have microwave diathermy units reported that they rarely administer a microwave diathermy treatment. Many physical therapists stated that they are using the diathermy modalities less, opting for mobilization techniques and the use of other heat sources, such as hot packs, whirlpool, ultrasound (high frequency sound wave), and galvanic stimulation. During a 20-minute treatment, the physical therapist does not always remain next to the unit console. Hence, physical therapists are not continuously exposed to RFR that may be leaking from the diathermy units. However, the physical therapists are usually located in a work area with other physical therapists and tend to be moving and working near activitated diathermy units. Consequently, a physical therapist may receive exposure from more than one diathermy unit in the work area.

The potential for exposure to RFR definitely exists for physical therapists who operate medical diathermy equipment in VA hospitals. These diathermy units are infrequently monitored for stray radiation. Since many of the diathermy units are in operation for many years before they need to be repaired or replaced, a physical therapist may unknowingly be exposed to excessively high levels of RFR, as noted in the studies by Bassen and others (1978) and Ruggera (1980). These studies indicated that physical therapists can be exposed to stray RFR exceeding 10 mW/cm^2. Because leakage occurs in the near-field region, these power density measurements actually refer to E-field leakage greater than 200 V/m and H-field leakage greater than 0.5 A/m. This level of exposure can occur each time a physical therapist operates a diathermy unit, so a physical therapist could accumulate a great deal of exposure to RFR over the years. Physical therapists employed in VA hospitals represent a viable population for studying the health effects associated with chronic, repetitive exposures to RFR that often exceed the ANSI recommendation.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of past employment responsibilities is necessary to determine if physical therapists who operate diathermy units could have been exposed to RFR in the past. Personnel and

Table 17. SUMMARY EVALUATION OF PHYSICAL THERAPISTS IN VA HOSPITALS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Types of Equipment - Shortwave and microwave diathermy units	Long-term use	Microwave diathermy rarely used Newer therapeutic techniques being phased in
Size of Population	1-5 diathermy units per VA hospital Estimated 750 physical therapists in VA hospitals Males and females	1-5 operators per hospital
Personnel Data	Available: - Standardized personnel records - Standardized medical records (two major health insurance plans) - Personnel and medical records kept locally - Employee health clinic in each VA hospital	High turnover rate
Extent of Exposures	Leakage documented Possible to reconstruct exposures	Exposures vary because physical therapist is not stationary Exposures vary by VA hospital
Control Group	Available from other departments within VA hospitals	Ensure no exposure to microwave/shortwave radiation

Table 18. SURVEY OF DIATHERMY EQUIPMENT USAGE IN 20 VA HOSPITAL PHYSICAL THERAPY DEPARTMENTS

VA Hospital Location	Number of Physical Therapists on Staff	Number of Diathermy Units and Type	Comments on Equipment Use
Baltimore, MD 21218	2	1 Birtcher SW Crusader 875	Used maybe once a month
Fort Howard, MD 21052	6	2 Birtcher MW 2 Burdick SW 1 Birtcher SW	Used 2 times per month
Richmond, VA 23249	11	1 Burdick MW	Geriatric facility rarely used
Hampton, VA 23667	5	1 Burdick MW Microtherm 2547 2 Burdick SW	
District of Columbia 20422	8	1 Birtcher SW Crusader 875	Not used often
Perry Point, MD 21902	7	1 Burdick SW	Not used often
Chicago, IL 60611	5	2 Burdick SW 490 1 Burdick MW	Used 3 times per month per patient
Hines, IL 60141	5	1 Burdick SW	Used may be 5 times per year
La Jolla, CA 92161	5	1 Burdick SW	Not used often
Loma Linda, CA 92357	8	1 Magnatherm SW	Not used often; if used, once daily per patient
Pittsburgh, PA 15240	8	2 Burdick MW (225)	Used maybe 2 times per month
Pittsburgh, PA 15206	3	1 Burdick SW	Used maybe once a year

SW = Shortwave
MW = Microwave

(Continued)

Table 18. (Continued)

VA Hospital Location	Number of Physical Therapists on Staff	Number of Diathermy Units and Type	Comments on Equipment Use
Syracuse, NY 13210	5	1 Metter SW 1 Burdick SW 2 Burdick MW	Used 5 times per day - orthopedic patients
Cincinnati, OH 45220	7	2 SW Machines	Not used anymore
Chillicothe, OH 45601	10	3 SW Burdicks	8 or 9 times per day
Dayton, OH 45428	6	3 SW Burdick 1 MW Birtcher	3 times per day
Brecksville, OH (part of Cleveland VA)	2	2 SW Birtcher 2 MW Burdick	1 time a week
Gainesville, FL 32602	2	None	Use ultrasound, swimming
Tampa, FL 33612	1	2 SW Burdick 1 MW Burdick	3 times per day
Lake City, FL 32055	1	1 SW Burdick 1 MW Burdick	Once a day Used rarely

SW = Shortwave
MW = Microwave

medical records need to be checked to assess the medical histories of both the physical therapists and the employees serving as controls.

It is quite likely that complete employment and medical data for persons working as physical therapists in VA hospitals could be obtained. Warren Smith of the VA's Rehabilitation Medicine Service stated that each VA hospital keeps standardized personnel and medical records for every employee. Each employee is given a physical examination at both the time of hiring and termination of employment. Each VA hospital has a "health evaluation unit" where employees can obtain aid if they are injured or become ill while working. Each time an employee reports to the employee health evaluation unit would be noted on that employee's medical record. Any major illness requiring compensation by insurance companies would also be recorded in the medical record. The VA offers many health insurance plans, but Smith estimated that almost all of their personnel are covered by either Aetna or Blue Cross/Blue Shield. Although Smith could not definitely say that the VA would cooperate in a study of physical therapists and the effects of RFR he believed that VA cooperation would be likely.

Norman Stier at the VA Medical Center Data Processing Division in Washington, D.C., informed us that when an employee terminates employment at a VA hospital, for any reason, the employee record is sent to the National Records Depository in St. Louis, Missouri, 30 days after termination. Local VA hospitals record all personnel actions taken for each employee on the employee Service Record Card, which is kept for three years after termination of employment, at which time it is purged from the VA hospital's data base. Table 19 shows the information kept for each VA hospital employee on the Service Record Card. This information is readily available and standard for physical therapists employed by VA hospitals. These data would be very useful in establishing personnel histories for a study population of physical therapists.

The availability of an appropriate control group must also be considered in evaluating the suitability of these physical therapists as a study population. Because physical therapists work in hospital rehabilitation areas, other devices, such as electronic monitoring and ultrasound equipment, may operate simultaneously with microwave/shortwave diathermy units. Interactions may occur between RFR and other variables in the environment. The interactions of these variables may contribute to adverse health effects that have been associated with exposure to RFR, and may make it difficult to isolate the effects attributable to RFR. To compensate for this factor, a control group would be required: one that does not use or operate RF-radiating equipment, but works in this same hospital environment. These control populations could include other professional groups employed by the VA hospitals, such as staff nurses, occupational therapists, lab technicians, or administrative personnel. These individuals work in the same environment as the physical therapists, but are not exposed to RFR.

As previously stated, the VA hospitals employ approximately 750 physical therapists, many of whom operate shortwave/microwave diathermy equipment. Identification of most, if not all, of these physical therapists is possible, since the VA has a unique code for physical therapists. This information is located at the VA's main data processing center in Austin, Texas. We believe

Table 19. INFORMATION ON VETERANS ADMINISTRATION HOSPITAL EMPLOYEE SERVICE RECORD CARD

Name

VA hospital code

Departure date and code (terminated, transferred, resigned, reassigned, retired, removed)

Date of birth

Veterans preference

U.S. citizen

Handicapped

Educational code (major, year of degree)

Hire date

Supervisor

Civil Service retirement fund or SSI (FICA)

Life insurance plan

Retired military

Reemployed annuitant

Type of appointment (career temporary, career conditional)

Service computation code (military service before, several jobs with break in service)

Current professional/proficiency rating

Hours worked during 26 pay periods

Reason for termination (retirement, new job)

Full/part time, intermittent

Position title

Pay plan (general schedule, wage grade)

Occupational code

Title code

Wage grade and step

Annual salary or hourly wage

Type of office

Medical center (outpatient, regional)

Location of VA facility

Eligible for increase 10 steps

Exempt/non-exempt

First day worked for VA center

Social Security number

that the VA will cooperate in a study of physical therapists, if arrangements are made with this Government agency through the appropriate channels.

8.2.2 Physical Therapists in Accredited Rehabilitation Facilities

The advantages and disadvantages of using physical therapists employed by accredited rehabilitation facilities as a study population are summarized in table 20. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

As shown in table 20, the average number of physical therapists employed by the rehabilitation facilities contacted was six, with a staffing range of 2 to 25.

We obtained a list of 170 accredited rehabilitation facilities in the U.S. that maintain programs in physical restoration from the Commission on Accreditation of Rehabilitation Facilities located in Tucson, Arizona. We then contacted 20 of these centers to determine population size and diathermy unit usage rates. Table 21 summarizes the information obtained from the physical therapy department in each facility. Physical therapist staffs ranged from 2 to 25. The 20 rehabilitation facilities surveyed had from 0 to 9 diathermy units, with shortwave units outnumbering microwave units by 23 to 11. One facility reported that they previously used diathermy equipment, but that they were now using other deep heating modalities. Many physical therapists stated that they are using diathermy modalities less, opting for mobilization techniques and other heat sources that induce a therapeutic effect. Most rehabilitation facility physical therapy departments that had microwave diathermy units reported that they rarely administered a microwave diathermy treatment.

Although the facilities contacted in this survey cooperated fully by answering all questions posed, it was not possible to ascertain whether or not all 170 accredited rehabilitation facilities would cooperate in a study of physical therapists exposed to RFR.

Also, estimating the number of physical therapists employed by these rehabilitation centers is not possible, since the facilities are usually privately owned and operated. To obtain an adequate population size, we would need to identify and secure the cooperation of 40 facilities that have an average of five physical therapists per hospital.

The potential for exposure to RFR definitely exists for physical therapists who operate medical diathermy equipment in accredited rehabilitation facilities. This exposure potential may be even greater than for physical therapists in VA hospitals, because these rehabilitation facilities care primarily for patients with chronic ailments who may require more diathermy treatments than patients in VA hospitals.

Diathermy units are infrequently monitored for stray radiation. With many of the units in operation for years before needing repair or replacement, a physical therapist may unknowingly be exposed to levels of RFR exceeding 10

Table 20. SUMMARY EVALUATION OF PHYSICAL THERAPISTS IN ACCREDITED REHABILITATION FACILTIES AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Types of Equipment - Shortwave and microwave units	Long-term use	Microwave diathermy rarely used New and safer therapeutic techniques being phased in
Size of Population	0-9 diathermy units per rehabilitation facility Males and females	2-25 operators per rehabilitation facility No estimate of total number of physical therapists employed by rehabilitation facilities
Personnel Data	Employee health clinic in each rehabilitation clinic Each maintains medical and personnel records	Difficult to retrieve non-standardized medical and personnel records
Extent of Exposures	Documented leakage Possible to reconstruct exposures	Exposures vary because physical therapist is not stationary Exposures vary by rehabilitation center
Control Groups	Available from other departments within rehabilitation center	Ensure no exposure to microwave/RF radiation

Table 21. SURVEY OF DIATHERMY EQUIPMENT USAGE IN 20 ACCREDITED PHYSICAL REHABILITATION FACILITIES

Center/Hospital	Number of Physical Therapists on Staff	Number of Diathermy Units and Type	Comments on Equipment Use
Huntsville Rehabilitation Center Huntsville, AL	4	1 SW Burdick	Used once a month
Sinai Hospital Dept. of Rehabilitation Medicine Baltimore, MD	25	5 SW Burdick 4 MW Burdick	SW used only 3x/week/patient MW used only 1 2x/year
Central Alabama Rehabilitation Center Montgomery, AL	4	None	Cannot afford to buy units
The Cathedral Rehabilitation Center Jacksonville, FL	7	None	Mostly geriatric patients
Curtis Hixon Rehabilitation Center, General Hospital Tampa, FL	7	1 MW Burdick 1 SW El Med	3 or 4x/week
Dept. of Rehabilitation Medicine Michael Reese Hospital and Medical Center, Chicago, IL	17	2 SW Burdick	50x week
Physical Medical and Rehabilitation Program, Mercy Hospital, Davenport, IA	2	1 SW Richmar	2-3x/day
St. Joseph Medical Center Wichita, KA	4	3 MW Burdick 1 MW Autotherm 1 SW Siemens	MW 2x/week SW once a week

SW = Shortwave
MW = Microwave

(Continued)

Table 21. (Continued)

Center/Hospital	Number of Physical Therapists on Staff	Number of Diathermy Units and Type	Comments on Equipment Use
Rehabilitation Unit, The Good Samaritan Hospital of Baltimore, MD	5	1 SW Burdick	Rarely used this year Used 30x last year
New Jersey Rehabilitation Hospital East Orange, NJ	2	1 SW Siemens	3x/week
Cardinal Hill Hospital Lexington, KY	7	None	Use ultrasound
Our Lady of Lourde Hospital, Regional Rehabilitation Center of Southern NJ Camden, NJ	2	1 SW Siemens	3-5x/week
Ruth B. Cowl Rehabilitation Center Laredo, TX	2	2 SW Birtcher	3x/month
Physical Rehabilitation Unit Memorial Hospital Glendale, CA	2	None	Had 2 SW Lindquist, not used anymore
Casa Colina Hospital for Rehabilitation Medicine Pomona, CA	2	None	Use ultrasound, hot packs
Northwestern Memorial Hospital, PT Dept Chicago, IL	5	3 SW Burdick	3x/week
Institute for Rehabilitation and Research Houston, TX		None	Use ultrasound

SW = Shortwave
MW = Microwave

(Continued)

Table 21. (Continued)

Center/Hospital	Number of Physical Therapists on Staff	Number of Diathermy Units and Type	Comments on Equipment Use
Mary Fru Bed Hospital and Rehabilitation Complex Grand Rapids, MI	19	1 SW Siemens	10x/week
Southwestern Michigan Rehabilitation Hospital Battle Creek, MI	4	1 SW Siemens 1 MW Burdick	3x/week/patient Rarely use microwave
Physical Medicine and Rehabilitation Service, The Hospital Center Orange, NJ	5	2 SW Siemens 1 MW Burdick	15-20x/week Rarely use microwave

SW = Shortwave
MW = Microwave

mW/cm^2. As noted previously, published documentation (Bassen et al. 1979; Ruggera 1980) indicated that physical therapists can be exposed to stray RFR. Based on this potential for exposure, physical therapists employed in accredited rehabilitation facilities represent a viable population for studying the health effects associated with chronic, repeated exposures to RF radiation.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of past employment responsibilities is necessary to determine if physical therapists who operate diathermy units were possibly exposed to RFR in the past. Personnel and medical records of both the physical therapists and the employees serving as controls need to be checked to assess the medical histories.

The likelihood of acquiring complete employment and medical data for physical therapists employed in rehabilitation facilities is promising, since most, if not all, of these facilities do have an employee health unit where employees go if they become ill while at work. Any major illness requiring reimbursement from hospitalization insurance would be recorded on the medical record. However, because the various rehabilitation facilities carry different insurance company plans, which use different record-keeping procedures and medical forms, these data could not be standardized. The same holds true for personnel records, as each rehabilitation facility has different record-keeping procedures and employment forms.

The availability of an appropriate control group must also be considered when evaluating the suitability of using physical therapists employed in rehabilitation facilities as a study population. Because these individuals are working in rehabilitation areas, they are exposed to other devices, such as electronic monitoring and ultrasound equipment, which are operated along with microwave/shortwave diathermy units. The possibility of interactions and other variables in the environment may make it difficult to isolate the causes of any adverse health effects that might be experienced by these physical therapists. To compensate for this factor, the control group must not use or operate RF-radiating equipment. Possible control groups are staff nurses, speech therapists, and occupational therapists. These individuals work in the same environment as the physical therapists, but are not exposed to RF radiation.

As previously stated, rehabilitation facilities employ a large number of physical therapists who operate microwave/shortwave diathermy units. Identification of most of these individuals will be difficult because there is no standardized medical or personnel record collection center as there is for the VA hospitals. The group of physical therapists is still a feasible study population, but the identification and study of these individuals might involve more time and money than would a similar study of physical therapists employed by VA hospitals.

8.3 COMMUNICATIONS AND NAVIGATION POPULATIONS

According to the criteria listed earlier in this chapter, three occupational groups within the communications and navigations populations considered would serve as suitable study groups for the health effects of exposure to non-ionizing radiation: school populations located near broadcasting towers, police and security officers, and radar technicians.

8.3.1 School Populations Located Near Broadcasting Towers

The advantages and disadvantages of using a school population as a study population are summarized in table 22. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

In the past ten years, EPA has conducted a number of surveys on potential population exposure to RF-emitting devices. It is generally believed that UHF and VHF broadcasting sources are the main source of environmental exposure to RF radiation. According to an EPA report (Tell and Mantiply 1978), the FM broadcast band (88-108 MHz) is responsible for creating the highest levels of environmental exposure. Two factors, relatively low tower heights and broad vertical antenna radiation patterns, account for the relatively high exposure levels from FM broadcasting sources. AM and UHF TV bands are relatively low contributors to environmental RF exposure.

FM antennas broadcast in a non-directional pattern at a line-of-sight distance. Antennas for FM stations are often located in densely populated areas because their effective broadcast distance is usually less than 30 miles. FM antennas are usually situated on broadcasting towers shared by a number of FM and TV broadcasting stations. There may be 10 to 15 broadcasting antennas on one tower, which increases the amount of radiation in the areas immediately adjacent to the broadcasting tower. These factors make broadcasting towers with antennas an appropriate source of RFR for an environmental study of the health effects of chronic, low level exposure to RF radiation.

A school population located near an FM broadcasting tower would be a good population to study. Unique data, such as mobility and attendance records, are available for school populations and may not be available for other institutional populations. A non-institutional population, as in a residential area, would not be a desirable study population because of diverse occupations and mobility patterns and the lack of standard records.

Using a school population would ensure a relatively large population size: the average population per school is 449 students. To obtain the desired population size, two or more schools could be used, or a retrospective or prospective study could be conducted at one school. This would allow more students than are currently attending the school to be included in the study.

The selection of the school appears to be the most difficult aspect of using a school population for study. The best school population to study would be the one located closest to a broadcasting tower. The best approach would be to map school and broadcasting tower locations by coordinates by using a computer to rank schools according to distance from broadcasting towers. However, this automated approach requires coordinated data bases for both FM broadcasting antenna locations and school locations.

Table 22. SUMMARY EVALUATION OF SCHOOL POPULATION LOCATED NEAR A BROADCASTING TOWER AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - FM broadcasting antenna	Creates highest levels of environmental exposure Broadcasts in non-directional pattern Located in densely populated areas Many antennas grouped together on one tower	
Population Size	Any size available	
Pertinent Data	Available: - School records on mobility, attendance, and scholastics - Personal interviews - Personal physician records - Medical insurance records	Non-standardized school and medical records Non-availability of complete data Parental permission needed to acquire data School cooperation needed
Extent of Exposure	General environmental exposure Possible to reconstruct exposure Chronic exposures	Level of exposure would be relatively low Shielding factors
Control Groups	Good availability - other school populations	Age

The FCC has a broadcasting data base called the FM Data base, which contains the station call letters, frequency and power, the city and State location, and antenna location coordinates. There is no complete school data base which lists school locations by coordinates. The Federal Emergency Management Agency (FEMA) maintains a data base called the National Shelter File, which gives the coordinates of schools surveyed in 1969 that meet national shelter qualifications. FEMA estimates that the percentage of schools identified in its data base would not represent 50 percent of the total number of schools in the U.S., and even fewer of the schools are identified by coordinates. The Department of Education maintains two data bases, the Public School Universe Tape and the Private School Universe Tape, which contain general information on all schools in the U.S., except in Georgia, Louisiana, and Michigan. However, these data bases do not contain school locations by coordinates.

Although there is no data base that gives school locations by coordinates, a "centroid" coordinate can be assigned to an address by using the zip code. FEMA maintains an automated zip code file that can assign a centroid coordinate to each zip code. We would, therefore, suggest using this zip code file to assign centroid coordinates to the schools listed in the two Department of Education school data bases.

By using the FCC FM Data Base and the Department of Education's data bases with centroid coordinates assigned, schools could be ranked according to their proximity to broadcasting towers. The school populations that are located the closest to broadcasting towers could then be selected.

The potential for exposure to RF radiation for a school population located near a broadcasting tower certainly exists. However, the exposure levels would probably be relatively low. According to a study by Janes (1979), the rates of exposure measured in the buildings located near broadcasting towers ranged from 0.01 mW/cm^2 to 0.001 mW/cm^2. The height of the tower and the distance to the broadcasting antenna affect the exposure rate. Therefore, the school selected for study would have to be quite close to a broadcasting tower. Exposure rates in the school could be determined.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of school attendance is necessary to determine if students have been exposed to RFR. School systems keep complete and standardized attendance and mobility records on each student. Mobility records would help to determine whether the students had any past exposure to RFR. Within a single school, all records would be standardized. However, according to all the school and health officials contacted, each school and school system is given a wide amount of latitude as to what information is included in its records and how the records are kept. Therefore, within a school system, each school could have a different record-keeping system. Using parochial schools might eliminate the problem of non-standardized record-keeping.

Unfortunately, acquiring complete medical records for students is unlikely. We learned from school and health officials that only immunization records are universally required. Schools often test for hearing and eye problems and may periodically require that students receive physical examinations, but these requirements are usually at the discretion of each school or school system. Each school does keep an emergency card on file for each student, which includes the name of the student's physician. All medical records would have to be retrieved from the student's personal physician, which would require parental permission. Since different physicians and group health insurance plans use different record-keeping procedures and medical forms, the data retrieved from these sources would not be standardized. However, these data would be important in establishing the medical histories of students included in the study population.

A school population located in an area with no broadcasting towers nearby would constitute a good control group. Certain factors, such as socioeconomic makeup and age group, would have to be considered when choosing a control group, but these do not appear to be difficult to control for in a school population. The socioeconomic level of a parochial school population might even be easier to control for. Although the control school's records would not necessarily be in the same format, they would have information on student mobility, attendance, and personal physicians. Therefore, we suggest selecting a similar school population, not located near a broadcasting tower, as a control group.

A number of other factors must be considered in using a school population as a study group. One very important factor is school and parental cooperation in such a study. To obtain much of the information needed would require the cooperation of school officials and/or parents. Another potential problem in studying a school population might be childrens' susceptibility to such minor illnesses as flu and stomach upsets. This susceptibility might cloud a study of the health effects of exposure to RF radiation. Finally, the shielding afforded by the school structure must be taken into account when attempting to reconstruct exposure rates.

Although such factors complicate the study potential, we believe that a school population located near a broadcasting tower would present a unique opportunity to study the effects of low level, chronic exposure to environmental RF radiation.

8.3.2 Police and Security Officers

Police and security officers use speed radar, two-way radios, and walkie-talkie devices, which emit RF radiation. The only group of police officers who consistently use walkie-talkies are metropolitan police on foot patrol. In contrast, security officers routinely use walkie-talkies. Therefore, police and security officers will be considered as two separate potential study groups.

Police Officers

The advantages and disadvantages of using State police as a study population are summarized in table 23. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

Table 23. SUMMARY EVALUATION OF STATE POLICE OFFICERS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - Two way radios	Standard within police department	Two-way radios may vary among police departments
Population Size	Average size - 1,000,; can aggregate several departments for larger population	
Personnel Data	Complete histories and medical histories Physicals required often	Work and medical histories would not be standardized among police departments
Extent of Exposure	Chronic low level exposure Documented exposure levels	
Control Group	Police assigned to desk jobs Teachers at police academies	Adequate size

Two-way radios are estimated to be the most widely used source of RFR (Ruggera 1977). There are over five million licensed two-way radio operators in the U.S. Although there are several two-way radio user populations that could be studied, we believe that State police would be the best study population. Using a State police population would ensure a large, standardized population and extensive, complete medical records. State police officers are also exposed to RF radiation from speed radar, which might enhance the population's rate of exposure. However, speed radar should be viewed only as a secondary and confounding source of RFR because it is not used consistently. The two-way radios used by State police forces operate on frequencies of 4.2 MHz, 154-155 MHz, or 460 MHz, and most are made by GE, Motorolla, or Aerotron. Speed radars operate at a power of about 100 mW.

On the average, State police forces have over 1,000 State troopers on motor duty, with the number varying according to the size of the State. Police officers often work for a State force for their entire career. Since States offer retirement plans after 20 to 30 years of service, most State police officers will have long-term, chronic histories of exposure to RFR from two-way radios and speed radar.

On the average, police officers on motor duty work in eight to ten hour shifts. The actual amount of time spent using the two-way radios can be determined by examining the taped conversations of their transmissions. The amount of time spent using speed radar can be determined from police records and logs.

The potential for exposure to RF radiation definitely exists for State police officers who use two-way radios and speed radar. Lambdin (1979)* documented the radiation levels in and near vehicles with mobile communications equipment and near hand-held walkie-talkies. Intensities varied, depending on the location of the antenna, location of measurement, and the distance from the antenna. Inside a car, the driver received the highest exposure (7.2 mW/cm^2) in the vicinity of his head. However, the typical exposure to a driver would be 0.06 to 2.4 mW/cm^2 at head level. Passengers were typically exposed to 0.02 to 0.2 mW/cm^2 at the head level. People outside of the vehicle received the highest levels of exposure at the corners of the rear fenders and wheel wells (7.2 mW/cm^2). The typical exposure of people outside a vehicle was 0.3 to 4.2 mW/cm^2.

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*All measurements of field intensities in this study were of the E field only and were expressed in units of nJ/m^3. This unit can be compared to the OSHA unit of mW/cm^2 in the following manner:

$$E(V/m)^2 \quad .00443 = E\ (nJ/m^3)$$

so

$$\frac{nJ/m^3}{.00443} \quad 3770 = E\ (mW/cm^2).$$

Therefore, E field power intensities originally expressed as nJ/m^3 in the study have been converted and are given in this report as mW/cm^2.

In addition to determining that the size of the population and the level of exposure are adequate for study, the availability of personnel and medical data for State police is another important factor to be considered. Personnel medical records are needed to assess the medical histories of both the State police and the personnel serving as controls.

State police forces maintain very good records on their employees, including complete and up-to-date work histories and standardized medical records. All State police forces require their employees to have regular physicals. Some States require physicals every year, while in others physical requirements are based on the age of the officer. State police forces usually employ one or two physicians who conduct the physicals.

The Virginia State Police require a complete physical when an officer joins the force, and a physical survey is then required yearly thereafter. This physical survey monitors medical data which are vital to good job performance, including blood pressure, vision, depth of vision, and weight. The police department maintains these records on its officers even after the officer has left the police force. Department personnel are currently converting these data for storage in a computer system. They also maintain insurance records, such as Blue Cross/Blue Shield or Worker's Compensation.

Most State police forces we contacted had similar programs for tracking the health of their officers. Therefore, obtaining good, standardized medical records would not be difficult within one State police department. However, if a number of State police forces are aggregated to compose a study population, different States would not necessarily keep the same records.

An appropriate control group may be police officers who have desk jobs, such as personnel officers, police academy instructors, and community liaison officers. One potential problem may be finding a large enough control group.

The State police forces that were contacted expressed some interest in the possible health hazards of radiation exposure from two-way radios and radar. However, the extent of expected voluntary cooperation in such a study could not be ascertained.

We recommend considering a State police officer population as a possible study population. Based on the chronic low level exposure, population size, and availability of pertinent data, State police officers are potentially a good study population. Table 24 lists the police departments that were surveyed and the information they provided.

Security Guards

The advantages and disadvantages of using security guards as a study population are summarized in table 25. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this group.

Using security personnel as a study population would afford a wide latitude in population size, depending on whether one agency was selected or a number of agencies were combined. To lessen the number of inconsistencies in

Table 24. SURVEY OF POLICE DEPARTMENTS

Population	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Groups
Virginia State Police	1313	Two-way radios & radar	Excellent medical & employment records		Probable	Desk officers & police academy teachers
Maryland State Police	1676	Two-way radios & radar	Excellent medical & employment records		Probable	Desk officers & police academy teachers
Delaware State Police	285	Two-way radios & radar	Excellent medical & employment records		Probable	Desk officers & police academy teachers
Fairfax County Police	300	Two-way Radios & radar	Excellent medical & employment records		Probable	Desk officers & police academy teachers

Table 25. SUMMARY EVALUATION OF SECURITY GUARDS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - walkie-talkies	Commonly used	
Population Size	Large populations of 2,000; can aggregate several agencies	
Personnel Data	Available: - Agency records - Medical insurance records - Personal interviews - Personal physician records	Difficult to retrieve standardized medical records Non-availability of complete data Need employee permission to acquire from private physician
Extent of Exposure	Documented exposure levels Chronic low level exposure Exposure to head and eye region	
Control Group	Maintenance men	Adequate size

records within a study population, we suggest using national agencies that employ large numbers of security personnel. Four of the largest employers of security personnel are Federal agencies: the General Services Administration (GSA) (2,800), the National Park Service (2,000), the Capitol Police (1,160), and the Secret Service (850). In addition, the Smithsonian Institution employs about 500 security personnel who not only use walkie-talkies, but also are exposed to microwave intrusion detection systems.

Security guards constantly use walkie-talkies to minimize the number of personnel needed to secure an area. Therefore, most security guards use walkie-talkies to maintain contact with other guards within a building and with security headquarters.

Most Government agencies use walkie-talkies made by GE, Motorola, or RCA. The general operating frequency ranges of walkie-talkies owned by the Government are 68-88 MHz, 30-54 MHz, 136-174 MHz, and 403-420 MHz. The potential for exposure to RFR definitely exists for security personnel who use walkie-talkies. According to Lambdin (1979), walkie-talkies are likely to create exposures that exceed 10 mW/cm^2: the maximum exposure to the head from walkie-talkies was greater then 12.0 mW/cm^2. It is interesting to note that the maximum field strength was located near the eye, which is close to the walkie-talkie antenna. The exposure rate diminished greatly within a few inches of the maximum intensity. Based on the possible population size and the potential for exposure, security guards would be a good population for a study of the health effects of chronic exposure to RF radiation.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of past employment responsibilities is necessary to determine if the security officers could have been exposed to RFR in the past. Personnel and medical records would be needed for both security officers and the employees serving as controls.

All of the Federal agencies we contacted maintain employment histories on their employees. Most Federal security guards work for an agency for a number of years. The only agency that had a high (one to three years) turnover rate was the Capitol Police, which employs a large number of law students. There should be little problem in reconstructing work histories for this population.

Acquiring complete medical histories for security guards is unlikely. Most agencies require a complete physical at the time of hiring; however, they do not require subsequent physicals. GSA requires its guards to take physicals when they begin training courses, which they do on the average of about once every two or three years. The Secret Service requires its security guards to pass annual physicals, but they generally do not maintain these records. Most security guards are covered by Blue Cross/Blue Shield, and each guard consults his or her personal physician for health problems. Therefore, most medical records would have to be retrieved from the employee's personal physician. Since different physicians use different record-keeping procedures and medical forms, the data retrieved from these sources would not be standardized. The data would not be consistent, but they would be useful in establishing the medical histories of security guards included in the study population.

A majority of the agencies contacted expressed some interest in the possible health hazards of radiation exposure from walkie-talkies. However, the extent of expected voluntary cooperation in such a study could not ascertained.

An appropriate control group may be maintenance people who work in the same Federal buildings as the security officers. Potential problems may be the adequacy of the control group's personnel and medical records, and their socioeconomic backgrounds.

Security guards are a feasible study population. Although gathering standardized medical data on such a population would be impossible, other factors, such as exposure and population size, make security guards a good potential study population. Table 26 lists the security guard agencies that were surveyed and the information they provided.

8.3.3 Radar Technicians

The advantages and disadvantages of using radar technicians as a study population are summarized in table 27. This information is meant to illustrate why this population was recommended for study, and some of the factors that must be considered when evaluating this study group.

Radar technicians are electronics technicians who maintain and service radar systems. Almost all of the navigation sources that were contacted expressed an interest in a study on radar technicians. Most of these sources indicated that in the routine maintenance of radar, a technician should not be exposed to RF radiation. They did concede, however, that proper maintenance procedures are not or cannot always be followed and, therefore, radar technicians are exposed to RFR. We do not feel that radar technicians would be the best population for a RFR study, but we are including them in this section because of the several recommendations we received from the sources contacted.

Although radar technicians work in civilian aviation, marine navigation, and the military, we suggest concentrating on a civilian aviation population of Federal Aviation Administration (FAA) radar technicians. We suggest using FAA radar technicians because the population size would be large, the records and the equipment would be standardized, the technicians are unionized, and there is an interest within both the FAA and the unions in seeing such a study conducted.

The FAA employs about 12,000 electronic technicians, and the FAA and union officials estimate that about 8,000 of these are radar technicians. These radar technicians could be isolated by Job Series Category (Number-856) (FAA 1973). Therefore, a study population of FAA radar technicians would be sizeable and could be selected easily and quickly.

The potential for exposure to RFR definitely exists for radar technicians. However, the amount of exposure and the extent of exposure to ionizing radiation lessens the feasibility of using such a population. If radar technicians do not violate safety procedures, they should not be exposed

Table 26. SURVEY OF SECURITY GUARD AGENCIES

Population	Sample Size	Type of Equipment	Personnel Data	Exposure Data	Cooperation	Control Group
General Services Administration	2800	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers
Park Service	2000	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers
Smithsonian	500	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers
Secret Service	850	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers
Capitol Police	1160	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers
Library of Congress	143	Walkie-talkie	Limited medical and employment records		Possible	Maintenance workers

[illegible] TECHNICIANS AS A STUDY POPULATION

Variable	Advantages	Disadvantages
Equipment - Radar	Standardized equipment	
Population Size	8,000	
Personnel Data	FAA records Medical insurance records Personal interviews Personal physician records Cooperation of unions	Non-standardized medical records Non-availability of complete data Need employee permission to acquire records from private physicians
Extent of Exposure		Isolated instances No documentation Impossible to reconstruct exposures Exposure to ionizing radiation
Control Group		None

to RFR. When inspecting and servicing radar, the technician is supposed to shut off the radar equipment. A radar technician cannot gain access to a radar tower to repair the antenna without unlocking a door, which automatically deactivates the radar.

A technician may connect the equipment to see if its working. At this point, the technician would be exposed to RFR, especially if he or she had not totally reassembled the equipment and the protective shielding was not in place. This type of exposure is not routine and would not be well documented. The FAA has conducted some general surveys of RFR in areas where radar technicians work. As indicated in a conversation with Bob Thompson, the agency has found that general exposure in the workplace is not detectable or is relatively insignificant.

Another factor that must be considered for radar technicians is exposure to ionizing radiation. Radar equipment not only produces microwave radiation, but it also produces x-ray radiation. A radar technician would be exposed to as much, if not more, ionizing radiation as non-ionizing radiation. This factor could make it difficult to correlate health effects with exposure to RF radiation.

In addition to determining that the size of the population and the level of exposure are adequate for study, an accurate assessment of past employment responsibilities is necessary to determine if these radar technicians could have been exposed to RFR in the past. Personnel and medical records would be needed for both radar technicians and the control group.

The FAA maintains accurate and up-to-date work histories on all its employees. There is very little turnover in the work force, although many come to the FAA from military backgrounds. Therefore, there would be little problem in reconstructing work histories for radar technicians.

Acquiring complete medical records for radar technicians is unlikely. The FAA only requires physicals and medical histories for certified employees, such as air traffic controllers and pilots. However, the majority of FAA employees are insured by Blue Cross/Blue Shield or Aetna and a certain amount of medical data could be retrieved from these insurance sources. For most medical problems, the employees would consult their own physicians. Consequently, most health data and medical histories would have to be retrieved through the employee's personal physician. Since different physicians and insurance plans use different record-keeping procedures and medical forms, the data retrieved from these sources would not be standardized.

There is a great interest in the health effects associated with working with radar in the aviation field. The Federal Aviation Science and Technology Association (FASTA), which represents the majority of the FAA's radar technicians, and the FAA have both expressed an interest in conducting an epidemiological study on radar technicans. Therefore, we would anticipate a high level of cooperation in such a study from the FAA and radar technician unions.

Based on the exposure characteristics of radar technicians, we feel they represent a less feasible population for a RF radiation study than some of our other populations. In addition, based on all the information we gathered and all the sources we contacted, we have as yet been unable to identify a suitable control group.

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BRH--See U.S., Department of Health and Human Services, Food and Drug Administration, Bureau of Radiological Health.

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FAA--See U.S., Department of Transportation, Federal Aviation Administration.

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JADA--See Council of Dental Materials Instruments and Equipment.

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U.S., Department of Health and Human Services, Food and Drug Administration, Bureau of Radiological Health. 1980. Radiological health: microwave diathermy products; performance standard. Fed. Regist. 45(147):50359-50368.

U.S., Department of Health and Human Services, Food and Drug Administration, Bureau of Radiological Health. 1981. An Evaluation of Radiation Emission from Video Display Terminals. (FDA-81-8153).

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APPENDIX A

Industrial and Commercial Sources

Name and Address	Date Contacted
Association of Home Appliance Manufacturers (1967) 20 North Wacker Drive, Chicago, IL 60606 (312) 984-5800 Pres.: Guenther Baumgart Members: 135-140 companies Staff: 40-50 Annual Budget: $1-2M	12/8/80
Electron Devices Soc. (1951) 345 East 47th Street, New York, NY 10017 Pres.: H.C. Natnairson Members: 7,500 AB: $250-500K Note: Scientists, students, engineers	11/10/80
Electronics Technicians Ass'n Internat'l (1978) 7046 Doris Drive, Indianapolis, IN 46224 (317) 241-7783 Pres.: Dick Glass Members: 600 Staff: 2-5 AB: $10-25K	11/7/80
Internat'l Microwave Power Institute (1966) 2111 E Street, New York, NY (212) 867-4480 Exec. Dir.: W. Tinga Members: 1200 AB: $50-100K Note: Non-Comm. aspects of MW power Publ: J. Microwave Power	12/8/80
Institute of Electrical and Electronics Engineers, Inc., The (1884) 345 East 47th Street, New York, NY 10017 (212) 644-7900 Exec. Dir.: Eric Herz Members: 190,000 Staff: 275-300 AB: Over $5M	11/12/80
American Electronics Association (1943) 2600 El Camino Road, Palo Alto, CA 94306 (415) 327-9300 Pres.: E. E. Ferrey, CAE Members: 1,200-1,300 Staff: 35-40 AB: $2-5M	11/7/80

Name and Address	Date Contacted
Rubber Manufacturers Ass'n, Inc., The (1900) 1901 Pennsylvania Avenue, N.W., Wash. D. C. 20006 (202) 785-2602 Pres.: Malcolm Lovell, Jr. Members: 195-200 Staff: 50-55 AB: $1-2M Note: Manufacturers of rubber products of all types	11/10/80
American Apparel Manufacturers Association, Inc. (1933) Suite 800, 1611 N. Kent St., Arlington, VA 22209 (703) 524-1864 Officer: Ellis Meredith, CAE Members: 650-700 Staff: 20-25 AB: $1-2M	11/7/80
Carpet and Rug Institute, The (1969) 310 Holiday Ave., Box 2048 Dalton, GA 30720 (404) 278-3176 Pres.: Richard Eldredge Members: 275-300 companies Staff: 16-20 AB: $500K-1M	11/7/80
American Concrete Institute (1905) P. O. Box 19150 Redford Station, Detroit, MI 48219 (313) 532-2600 Exec. Dir.: George Leyh Members: 15-16,000 individuals, 5-600 organizations Staff: 40-45 AB: $2-5M	11/7/80
Nat'l Concrete Masonry Association (1920) Box 781, Herndon, VA 22070 (703) 435-4900 Pres.: Paul Lenchuk, Jr. (AE) Members: 750-800 companies Staff: 6-25 AB: $2-5M Note: Members are manufacturers of concrete blocks and supplies	11/10/80
Nat'l Food Processors (1907) 1133 20th Street, N.W., Washington, D. C. 20036 (202) 331-5900 Pres.: Charles Carey Members: 500-600 companies Staff: 125-150 AB: $2-5M	11/12/80
American Frozen Food Institute (1942) 1700 Old Meadow Road, McLean, VA 22102 (703) 821-0770 Pres.: Thomas House Members: 400-500 Staff: 16-20 AB: $500K-1M	11/12/80

Name and Address	Date Contacted
Food Processing Machinery & Supplies Ass'n (1885) Suite 700, 828 "L" St., N.W., Washington, D.C. 20036 (202) 833-5770 Pres.: Dewey Clower Members: 450-475 companies Staff: 7 AB: $500K-1M	11/12/80
Potato Chips/Snack Foods Ass'n. (1937) 1735 Jefferson Davis Hwy. #903, Arlington, VA 22202 (703) 920-4805 Exec. VP: Lawrence Burch Members: 500-550 Staff: 6-10 AB: $500K - 1M	11/7/80
Potato Ass'n. of America (1913) 114 Deering Hall, Univ. of Maine, Ororo, ME 06473 (207) 581-2771 Sec.: Hugh Murphy Members: 1500-1600 Staff: 2-5 AB: $25-50K	11/7/80
National Frozen Food Ass'n. (1945) Box 398, Hershey, PA 17033 (717) 534-1601 Exec. VP: Richard Funk, CAE Members: 1300-1350 companies Staff: 11-15 AB: $500K - 1M	11/12/80
Adhesives Manufacturers Ass'n. of America (1933) 111 East Wacker Drive, Chicago, IL 60601 (313) 644-6610 Exec. Sec: Sanford Hill Members: 150 individuals, 35 companies Staff: 2-5 AB: $50-100K	11/10/80
Adhesive & Sealant Council, Inc. The (1957) Suite 1117 1500 Wilson Blvd., Arlington, VA 22209 (703) 841-1112 Exec. Pres.: Jules Rapp Members: 115-125 companies Staff: 2-5 AB: $250-500K	11/10/80
American Ass'n. for Textile Technology, Inc. (1934) 1040 Ave. of the Americas, New York, NY 10018 (212) 354-5188 Admn.: Ms. Karen Stone Members: 1500-1500 Staff: 2-5 AB: $25-50K	11/10/80

Name and Address	Date Contacted
American Textile Manufacturers Institute, Inc. (1949) Suite 300, 1101 Conn. Ave., N.W., Washington, D.C. 20036 (202) 862-0500 Pres.: Ray Shockley Members: 275-300 Staff: 40-45 AB: $1-2M	11/10/80
Ass'n. of Synthetic Yarn Manufacturers (1970) Box 66, 601 West Franklin St., Gastonia, NC 28052 (704) 867-7201 Exec. Dir.: Jim Conner Members: 45-50 companies Staff: 2-5 AB: $25-50K	11/10/80
Nat'l. Forest Products Ass'n. (1902) 1619 Mass. Ave., N.W., Washington, D.C. 20036 (202) 797-5800 Exec. Pres.: Ralph Hodges, Jr. Members: 40-45 forest industry associations and companies AB: $2-5M Staff: 75-100	11/10/80
Technical Ass'n. of the Pulp and Paper Industry, Inc. (1915) One Dunwoody Park, Atlanta, GA 30338 (404) 394-6130 Exec. Dir.: Dr. Philip Nethercut, CAE Members: 15-16,000 Staff: 35-40 AB: $2-5M	11/10/80
Pulp & Paper Machinery Manufacturer's Ass'n. (1933) Suite 607, 1707 H Street, N.W., Washington, D.C. 20006 (202) 298-6344 Exec. Dir.: Frank McManus, Jr. Members: 31 companies Staff: 2-5	11/11/80
Hardwood Plywood Manufacturers Ass'n. (1921) 1821 Michael Faraday Dr., Box 2789, Reston, VA 22090 (703) 435-2900 Dir.: Clark McDonald, CAE Members: 150-200 Staff: 16-20 AB: $500K-1M	11/11/80
Urethane Foam Contractors Ass'n. (1974) 1406 Third National Bldg., Dayton, OH 45902 (513) 223-0419 Exec. Sec.: Vernum Lowe Members: 410 companies Staff: 11-15 AB: $50-100K	11/11/80

Name and Address	Date Contacted
Urethane Institute (1959) 355 Lexington Ave., New York, NY 10017 (212) 573-9400 Exec. Sec.: Bert S. Montell Members: 45-50 companies Staff: 2-5	11/11/80
National Ass'n. of Plastic Fabrications, Inc. (1956) 1701 N Street, N.W., Washington, D.C. 20036 (202) 223-2504 Dir.: Mrs. Jill Wettrich Members: 200-210 companies Staff: 2-5 AB: $100-250K Note: Makers of plastic laminate, such things as kitchen counters, desk tops, etc.	11/11/80
Plastic Soft Materials Manufacturers Ass'n. (1937) 225 West 34th Street, New York, NY (212) 564-2500 Exec. Dir.: Sheldon M. Edelman Members: 80-90 Staff: 2-5 AB: $50-100K	11/11/80
Plastic & Metal Products Manufacturers Ass'n., Inc. (1937) 225 West 34th Street, New York, NY 10001 (212) 564-2500 Dir.: Sheldon Edelman Members: 150-200 Staff: 6-10 AB: $100-250K	11/11/80
Plastic Container Manufacturers Institute (1962) 54 Apple Street, Tinton Falls, NJ 07724 (201) 741-3800 Sec.: R. E. Hartung Members: 40-50 Staff: 1 AB: Under $10K	11/12/80
Organization of Plastics Processors, The (1974) 53 Church Street, Stonington, CT 06378 (203) 535-3869 Exec. Pres.: Lee R. Noe Members: 200-225 companies Staff: 2-5 AB: $50-100K	11/12/80
American Pulpwood Ass'n. (1934) 1619 Mass. Ave., N.W., Washington, D.C. 20036 (202) 265-0670 Exec. Pres.: K. S. Rolsten, Jr. Members: 350-400 companies Staff: 16-20 AB: $500K-1M	11/12/80

Name and Address Date Contacted

American Paper Institute, Inc. (1964) 11/12/80
260 Madison Ave., New York, NY 10016
(212) 34-0600
Pres.: Lovis Laun
Members: 200 companies Staff: 130
AB: over $5M

Photographic Soc. of America (1933) 11/12/80
2005 Walnut Street, Philadelphia, PA 19103
(215) 563-1663
Exec. Dir.: Harold Vernes
Members: 19,000 Staff: 11-15
AB: $200-500K

Photographic Manufacturers & Distributors Ass'n., Inc. (1939) 11/12/80
866 United Nations Plaza, Suite 436, New York, NY 10017
(212) 688-3520
Exec. Man.: Norman Lipton
Members: 65 companies Staff: 1
AB: $10-25K

Suede & Leather Refinishers of America (1954) 11/11/80
5514 Beacon Hills Court, Seven Hills, OH 66131
(216) 771-1142
Sec. Treas: Wilma Siclad
Members: 70-80 companies Staff: 1
AB: under $10K

Luggage & Leather Goods Manufacturers of America (1938) 11/11/80
220 Fifth Ave., New York, NY 10017
(212) 532-3960
Exec. Pres..: Jack Litronbaum
Members: 175-200 Staff: 2-5
AB: $50-100K

Tanners Council of America, Inc. (1917) 11/12/80
411 Fifth Ave., New York, NY 10016
(212) 686-7950
Pres.: Eugene Kilik
Members: 300-350 companies Staff: 11-15
AB: $250-520K

Clothing Manufacturers Ass'n. of the USA (1907) 11/13/80
135 West 50th St., New York, NY 10020
(212) 757-6664
Exec. Sec.: Robert Kaplan
Members: 350-400 Staff: 2-5
AB: $100-250K

Name and Address	Date Contacted
Foundry Equipment Manufacturers Ass'n. (1919) 1000 Vermont Ave., N.W., Washington, D.C. 20005 (202) 628-4634 Exec. Dir.: Charles Perry Members: 65-770 companies Staff: 2-5 AB: $50-100K Note: Makers of foundry equipment & supplies	11/13/80
Bakery Equipment Manufacturers Ass'n. (1918) Suite 600, 111 East Wacker Dr., Chicago, IL 60601 (312) 644-6610 Sec. Treas.: William Carpenter Members: 100 companies Staff: 2-5	11/11/80
Timber Products Manufacturers (1916) 951 East Third St., Spokane, WA 99202 (509) 535-4646 Manager: George Tichy Members: 300-325 Staff: 6-10 AB: $250-500K	11/12/80
American Ass'n. of Meat Processors (1939) 224 East High St., Elizabethtown, PA 17022 (717) 367-1168 Exec. Dir.: Robert Madeira Members: 1400-1500 Staff: 6-10 AB: $100-250K	11/12/80
Hospital Institution and Educational Food Service Soc. (1960) 4410 W Roosevelt Rd., Hillside, IL 60152 (312) 449-2770 Exec. Dir.: Mrs. Jean Denwood, R.N. Members: 12,000 individuals Staff: 6-10 AB: $50CK-1M	11/12/80
Nat'l. Independent Meat Packers Ass'n. (1942) 734 15th St., N.W., Washington, D.C. 20005 (202) 347-1000 Pres.: John Mohay Members: 475-500 Staff: 11-15 AB: $500K-1M	11/12/80
Ass'n. of Industrial Metallizers, Coaters & Laminators (1955) 61 Blue Ridge Rd., Wilton, CT 06897 (203) 762-5611 Exec. Dir.: William Troph Members: 75-80 companies Staff: 2-5 AB: $50-100K	11/12/80

Name and Address	Date Contacted
American Pipe Fittings Ass'n. (1938) 26 Sixth St., Stamford, CT 06905 (203) 348-6459 Exec. Dir.: Paul Engle, Jr. Members: 45-50 companies Staff: 2-5 AB: $50-100K	11/12/80
Plastic Pipe Institute (1949) 355 Lexington Ave., New York, NY 10017 (212) 573-9400 Exec. Dir.: Stephan Klaurke Members: 60-75 Staff: 2-5 AB: $500K-1M	11/12/80
Plastic Pipe & Fittings Ass'n. (1978) 490 Penn. Ave., Glen Ellyn, IL 60137 (312) 858-7337 Exec. Dir.: Richard Church Members: 60-70 companies Staff: 2-5 AB: $100-250K	11/12/80
Pipe Fabrication Institute (1913) 1326 Freeport Rd., Pittsburgh, PA 15238 (412) 782-1624 Exec. Dir.: James Whipkey Members: 25-30 Staff: 2-5 AB: $50-100K	11/12/80
Welded Steel Tube Institute (1930) 522 Westgate Tower, Cleveland, OH 44116 (216) 333-4550 Exec. Dir.: Robert Baeddener Members: 35-40 companies Staff: 2-5 AB: $100-250K	11/12/80
Waterbed Manufacturer's Association 1411 Olympic Blvd., Los Angeles, CA (213) 384-3179 Members: 165 companies AB: $250-500K Staff: 20-40	01/8/81
International Ladies Garment Workers Union 1710 Broadway, New York, NY (212) 265-7000 Members: 350,000 AB: $5M Staff: 1,200	01/8/81

Name and Address	Date Contacted
United Steelworkers of America Five Gateway Plaza, Pittsburgh, PA (412)562-2400 Members: 1,400,000 AB: over $5M Staff: 1,400	01/16/81
International Chemical Workers Union 1655 W. Market St., Akron, OH (216) 867-2444 Members: 65,000 AB: over $5M Staff: 40-50	01/22/81
Solidyne Corporation Bay Shore, NY	11/25/80
Batson Machinery Greenville, NC	11/11/80
Reeves Urethane Foam Auburn, IN	11/11/80
Thermatool Stamford, CT	11/12/80
Beardsley Paper Company Chicago, IL	11/13/80
Reeve Electronic Chicago, IL	11/13/80
Despatch Oven Corporation Minneapolis, MN	11/13/80
Cober Electronics Stamford, CT	11/13/80
Goodyear Tire & Rubber Company Akron, OH	11/14/80
Blair Plastics Chicago, IL	11/14/80
Meda Plast Philadelphia, PA	11/14/80
Engineered Yarns Coventry, RI	11/14/80

Name and Address	Date Contacted
Synthetic Thread Company Bethlehem, PA	11/14/80
Tracies Corporation Holyoke, MA	11/25/80
Plastic Services & Supply Erwin, TN	11/25/80
Best Seal Corporation New York, NY	11/25/80
Rubber & Plastic Corporation Lynn, MA	11/25/80
Engineered Monofilaments Wellston, NJ	11/25/80
Hobart Oven Company Troy, OH	11/25/80
Gerling-Moore Santa Clara, CA	11/25/80
White-Westinghouse Corporation Pittsburgh, PA	11/25/80
Republic Steel Corporation Cleveland, OH	11/25/80
Speco Corporation Beverly, MA	11/25/80
PSC, Inc. Cleveland, OH	11/25/80
Litton Microwave Corporation Minneapolis, MN	12/3/80
J. Lenco Foundry Cores Morral, OH	12/3/80
Hooker & Saunders Textiles New York, NY	12/3/80
Monsanto Rubber Testing Institute Akron, OH	12/3/80
Firestone Tire & Rubber Company Akron, OH	12/2/80

Name and Address	Date Contacted
Armada Rubber Company Armada, MI	12/2/80
Franklin Fiber-Lamitex Wilmington, VT	12/2/80
Johns-Mansville Denver, CO	12/2/80
Thermatron Insulation Ft. Wayne, IN	12/2/80
Carborundum Insulation Niagara Falls, NY	12/2/80
Alpha Tube Company Toledo, OH	12/8/80
Higbie (ITT) Tube Company Rochester, MI	12/8/80
Donovan Steel Tube Company Toledo, OH	12/8/80
Callier Pipe & Tube Company St. Louis, MO	12/9/80
Raytheon Company Waltham, MA	12/9/80
EPSCO Microwave Westwood, MA	12/9/80
Adenco Burgler Alarms Syosset, NY	12/9/80
Century Plastics, Inc. Compton, CA	12/9/80
Dura Plastics Bridgeport, CT	12/9/80
Beltsville Vinyl Plastic Company Beltsville, MD	12/9/80
Cadillac Plastic Products Sterling Heights, MI	12/9/80
Baer Plastic Fabricators Hillside, NJ	12/9/80

Name and Address	Date Contacted
Leland Tube Company South Plainfield, NJ	12/9/80
A. Smith & Co. (canvas) Philadelphia, PA	01/13/81
Union Canvas Products Carlstadt, NJ	01/13/81
Canvas Products Co. Oak Park, MI	01/13/81
A.L. Robertson Corp. Baltimore, MD	01/13/81
Bethlehem Steel Tubing Baltimore, MD	01/28/81
Armco Steel Co. Middletown, OH	01/29/81
Leelyn Plastics Springdale, AR	01/21/81
J.A. Callanan Co. Chicago, IL	01/21/81
Apex Plastics Dania, FL	01/21/81
Arrow Plastics Dorchester, MA	01/23/81
Command Plastics Akron, OH	01/23/81
Fabrico Plastics Chicago, IL	01/23/91
Daily Steel Corp. Montgomeryville, PA	02/4/81
Bundy Tubular Steel Hometown, PA	02/3/81
Copperweld Tubing Co. Chelby, OH	02/3/81
Tuesday Industries Cornwells Heights, PA	02/27/81

APPENDIX B

Medical and Therapeutic Sources

Name and Address	Date Contacted
Ass'n. for Health Records (1969) CWRU School of Medicine, Cleveland, OH 44106 (216) 229-9744 Exec. Dir.: William Kincaid Members: 450-500 Staff: 2-5 AB: $10-25K Note: Individuals involved in the use of health records to measure the quality of health care.	11/7/80
Health Insurance Ass'n. of America (1956) 1750 K St. N.W., Washington, D.C. 20006 (202) 331-1336 Pres.: Robert Froehlke Members: 300-350 Staff: 60-70 AB: Over $5 million Note: Members are accident & health insurance companies.	11/7/80
Group Health Ass'n. of America, Inc. (1959) 1717 Mass. Ave., N.W., Washington, D.C. 20036 (202) 483-4012 Exec. Dir.: Jeffery Cohelan Members: 1000-1100 Staff: 20-25 AB: $500K-1M Note: Members are group practice prepayment health plans, related org's, and individuals supporting the HMO movement.	11/7/80
Health Associated Representatives (1978) Box 1321, Mission, KS 66222 (913) 262-4510 Exec. Dir.: Frank Bistrom Members: 70-80 Staff: 2-5 AB: $25-50K Note: Manufacturers' representatives who sell medical equipment and other products in the health care field.	12/9/80
Health Industry Manufacturers Ass'n. (1903) 1030 15th St., N.W., Washington, D.C. 20005 (202) 452-8240 Pres.: Harold Buzzell Members: 250-300 companies Staff: 25-30 AB: $1-2 million Note: Domestic manufacturers of medical devices and diagnostic products. Reviews product standards, legislation and regulations affecting the industry.	12/8/80

Name and Address	Date Contacted
American Hospital Ass'n. (1898) 840 North Lake Dr., Chicago, IL 60611 (312) 280-6000 Pres.: John Alexander McMahon Members: 6500 institutions Staff: 700 AB: over $5 million Note: Maintains a Washington office, too. Many divisions, i.e., American Society for Hospital Purchasing and Materials Management.	12/8/80
Federation of American Hospitals, Inc. (1966) Suite 810, 1101 17th St., N.W., Washington, D.C. 20036 (202) 833-3070 Ex. Dir.: Michael Bromberg Members: 650-700 hospitals Staff: 16-20 AB: $500K-1 million Note: Investor-owned hospitals.	12/8/80
Hospital Bureau, Inc. (1910) 80 Wheeler Ave., Pleasantville, NY 10570 (914) 769-6800 Pres.: Peter B. Terenzio Members: 1300 hospitals Staff: 60-65 AB: $1-2 million Note: Hospital Bureau is a purchasing cooperative.	12/8/80
Nat'l. Ass'n. of Hospital Purchasing Materials Management (1957) Suite 3342, 875 North Michigan Ave., Chicago, IL 60611 (312) 440-0077 Exec. Dir.: Betty Hanna Members: 1000-1100 Staff: 2-5 AB: $25-50K Note: Members are individuals in administrative positions in the purchasing departments of health care institutions.	12/8/80
American Nurses Ass'n., Inc. (1896) 2420 Pershing Rd., Kansas City, MO 64108 (816) 474-5720 Exec. Dir.: Dr. Myrtle Aydelotte Members: 170-180,000 Staff: 170-180 AB: $39 million	12/9/80
American Academy of Physical Medicine & Rehabilitation (1938) Suite 922, 30 North Michigan Ave., Chicago, IL 60602 (312) 236-9512 Exec. Dir.: Creston Herold Members: 950-1000 Staff: 6-10 AB: $100-250K	11/19/80

Name and Address	Date Contacted
American Physical Therapy Ass'n. (1921) 1156 15th St., N.W., Washington, D.C. 20005 (202) 466-2070 Exec. Dir.: Royce Noland, CAE Members: 30,000 individuals Staff: 50-55 AB: $1-2 million	11/19/80
Nat'l. Ass'n. of Physical Therapists, Inc. (1961) Box 367, West Covina, CA 91793 (213) 331-4066 Sec.: Shela Deuton Members: 36-3700 Staff: 2-5 AB: $10-25K	11/19/80
Nat'l. Ass'n. of Pharmaceutical Manufacturers (1965) 747 Third Ave., New York, NY 10017 (212) 838-3720 Exec. Dir.: George Schwartz Members: 125-150 Staff: 2-5	12/9/80
Pharmaceutical Manufacturers Ass'n. (1958) 1155 15th St., N.W., Washington, D.C. 20005 (202) 296-2440 Pres.: Lewis Engmar Members: 130 Staff: 90-100 AB: over $5 million	12/8/80
Insurance Information Institute New York, NY (212) 233-7650	11/7/80
American Council of Life Insurance Washington, D.C. (202) 862-4000	11/7/80
Association for Advancement of Medical Instrumentation 1902 North Fort Myer Dr., Suite 602 Arlington, VA 22209 (703) 525-4890	12/15/80
KOL Biomedical, Inc. 7950 Woodruff Court Springfield, VA (703) 323-7100	12/10/80
American Society of Clinical Pathologists 2100 W Harrison Chicago, IL 60612 (312) 738-1336	12/2/80

Name and Address	Date Contacted
American Association of Pathologists 9650 Rockville Pike Bethesda, MD 20014 (301) 530-7130	12/2/80
American Osteopathic College of Pathologists 2160 Idlewood Rd. Tucker, GA 30084 (404) 938-2811	12/2/80
American Academy of Oral Pathology School of Dentistry University of Michigan Ann Arbor, MI 48109 (313) 764-1535	12/8/80
International Academy of Pathology 1003 Chafie Ave. Augusta, GA 30904 (404) 724-2973	12/9/80
Georgetown University Hospital Pathology Dept. 3800 Reservoir Rd., N.W. Washington, D.C. 20007 (202) 625-2873	12/8/80
Georgetown University Hospital Radiation Biology Dept. 3800 Reservoir Rd., N.W. Washington, D.C. 20007 (202) 625-7901	12/8/80
Fishers-Stevens Publishing Company 120 Brighton Rd. Clifton, NJ (201) 790-0909	12/9/80
American Chiropractic Association 2200 Grand Ave. Des Moines, IA 50312 (515) 243-1121	12/9/80
American Electrolysis Association Box 204 Evanston, IL 60204 (312) 623-6100	12/9/80
Radiation Physics, Inc. 811 Dale Dr. Silver Spring, MD (301) 565-9595	12/8/80

Name and Address	Date Contacted
D.C. Medical Society 2007 Eye St. N.W., Washington, D.C. (202) 379-3116	12/9/80
Northern Virginia Community College Department of Physical Therapy Annandale, VA (703) 323-3414	01/15/81
Howard University Department of Physical Therapy Washington, D.C. (202) 636-7615	01/16/81
Veterans Administration Washington, D.C. (202) 389-2373	
American Association of Gynecological Laparoscopists 11239 S. Lakewood Blvd. Downey, CA 90241 (213) 862-8181	02/19/81
American College of Obstetricians and Gynecologists Chicago, IL	02/19/81
American Veterinary Medical Association 1522 K St., N.W. Washington, D.C. (202) 659-2040	02/19/81
American Society for Gastro-Intestinal Endoscopy 13 Elm Street Manchester, MA (617) 227-0760	02/19/81
Commission on Accreditation of Rehabilitation Facilities 2500 North Pantano Road Tucson, AZ 85715 (602) 886-8575	01/9/81
American Dental Association 1101 17th St., N.W. Washington, D.C.	01/29/81
American Dental Trade Association 1140 Connecticut Ave. N.W. Washington, D.C.	01/29/81

Name and Address	Date Contacted
American Association of Blood Banks Suite 608 1828 L St., N.W. Washington, D.C. (202) 737-8333	02/24/81
Red Cross Blood Program 2025 E ST., N.W. Washington, D.C. (202) 737-3692	02/24/81
Neomed, Inc. 5595 Arapahoe Boulder, CO (800) 525-2693	02/13/81
Soybron, Inc. P.O. Box 23077 Rochester, NY (716) 475-1400	01/19/81
Electromedical Systems (EMS) Denver, CO (800) 525-7046	01/19/81
Valleylab 5920 Longbow Drive P.O. Box 9015 Boulder, CO (303) 530-2300	01/21/81
Cameron-Miller, Inc. 3949 South Racine Chicago, IL (312) 523-6360	02/26/81
Porkill, Inc. Farmingdale, NY (516) 249-1134	02/2/81
Ellman, Inc. Hewlitt, NY (516) 569-1482	02/2/81
Whaledent, Inc. New York, NY (212) 481-5353	02/2/81
Kree International 1500 Broadway New York, NY (212) 730-9700	01/19/81

Name and Address	Date Contacted
Instatron, Co. 3122 Pawtucket Ave. Providence, RI	01/19/81
Sudonna, Inc. 5 Park Avenue Westwood, NJ (201) 664-7333	01/21/81
Proteus, Inc. P.O. Box 211 Bellingham, MA (617) 883-1020	01/30/81
Birtcher Corporation El Monte, CA (213) 575-8144	12/3/80
Sanitex Corporation New York, NY (212) 686-3239	12/2/80
Mettler Electronics Anaheim, CA (714) 533-2221	12/3/80
Merit Short Wave Diathermy Los Angeles, CA (213) 261-7521	12/3/80
Lindquist Corporation Los Angeles, CA (213) 382-1268	12/3/80
R. A. Fischer Company Glendale, CA (213) 241-1178	12/3/80
Burdick, Inc. Milton, WI (608) 868-7631	02/25/81
Local chiropractors	12/3/80
Local electrolysis clinics	12/3/80

APPENDIX C

Communication and Navigation Sources

Name and Address	Date Contacted
Armed Forces Communications & Electronics Ass'n. (1946) Suite 301, 5205 Leesburg Pike, Falls Church, VA 22041 (703) 820-5028 Exec. Pres.: Lawrence E. Adams, Brig. Gen., USA, (Ret.) Members: 16,000 Staff: 11-15 AB: $250-500,000 Note: Fosters cooperation between government and all branches of the communications industry.	12/3/80
Communications Workers of America (1939) 1925 K St., N.W., Washington, D.C. 20006 (202) 785-6700 Pres.: Glenn E. Watts Members: 500-525,000 Staff: 225-250	12/2/80
Special Industrial Radio Service Ass'n., Inc. (1953) Suite 602, 1901 N. Moore St., Rosslyn, VA 22209 (703) 528-5115 Pres.: Mark Crosby Members: 12,840 Staff: 16-20 AB: $250-500,000 Note: Designated by the FCC in 1953 as the official Frequency Advisory Committee for the Special Industrial Radio Service. Formed to represent the interest of its members concerning 2-way radio communications.	12/3/80
Telocator Network of America (1949) Suite 1020N, 1800 M St., N.W., Washington, D.C. 20036 (202) 659-6446 Exec. Dir.: Thomas Lemoureux Members: 375-400 Staff: 2-5 AB: $500-1,000,000 Note: Members and radio common carriers who operate paging systems and mobile radio-telephone networks. Also encompasses manufacturers of mobile radio equipment.	12/3/80
American Radio Ass'n. (1948) 270 Madison Ave., New York, NY 10016 (212) 689-5754 Pres.: William R. Steinberg Members: 700 ship radio operators Staff: 6-10 AB: $500-1,000,000 Note: Labor union affiliated with AFL-CIO.	12/3/80

Name and Address	Date Contacted
Ass'n. of Maximum Service Telecasters, Inc. (1956) 4th Floor, 1735 De Sales St., N.W., Washington, D.C. 20036 (202) 347-5412 Pres.: Tom E. Paro Members: 200-300 TV Stations Staff: 2-5 Note: All those who own and operate TV stations, UHH or VHF.	12/2/80
International Union of Electrical, Radio, and Machine Workers (1949) 1126 16th St., N.W., Washington, D.C. 20036 (202) 296-1200 Pres.: David Fitzmaurice Members: 250,000 Staff: 200-225 AB: $17 million	12/2/80
Nat'l. Ass'n. of Broadcast Employees & Technicians (1934) Suite 1303, 7101 Wisconsin Ave., Bethesda, MD 20014 (301) 657-8420 Pres.: Edward Lynch Members: 7-8000 Staff: 6-10 AB: $2-5 million Note: An industrial union.	12/3/80
United Electrical, Radio & Machine Workers of America (1936) 11 East 51st St., New York, NY 10022 (212) 753-1960 Pres.: Denis Glavin Members: 160-170,000 Staff: 60-70 AB: $2-5 million	12/3/80
National Communications Ass'n., Inc. (1955) Suite 311, 485 Fifth Ave., New York, NY 10017 (212) 682-2627 Pres.: Arlken Lessin Members: 100-125 companies Staff: 12 AB: $10-25,000 Note: Companies making and selling privately marketed communications equipment such as telephone and data systems, intercoms, pagers, security and fire alarms.	12/3/80
North American Telephone Ass'n. (1968) Suite 360, 1030 15th St., S.W., Washington, D.C. 20005 (202) 393-7444 Dir.: Richard Long Members: 300-350 companies Staff: 10-15 AB: $1-2 million Note: Private manufacturers and installers of telephone equipment not regulated by the FCC. The so-called "interconnect" industry.	12/3/80

Name and Address	Date Contacted
United States Independent Telphone Ass'n. (1897) 1801 K St., N.W., Suite 1201, Washington, D.C. 20006 (202) 872-1200 Exec. Pres.: George Pickett Members: 35-40 companies Staff: 30-35 AB: $2-5 million Note: Represents 96% of the US non-Bell System telephone industry.	12/3/80
Communication Union Canada (1945) merged in 1979 with Communication Workers of Canada (1972) Rm. 211, Brent Bldg., 2505 11th Ave. Regina, Saskatchewan S49 OK6 (306) 522-0334 Sec. Treas.: R. M. Wyatt Members: 17-17,500	12/3/80
Associated Public Safety Communications Offices (1935) Box 669, New Smyrna Beach, FL 32069 Exec. Dir.: Ernest J. Laudreville (904) 428-8700 Member: 3,500 Staff: 6-10 AB: $250-500,000	12/3/80
Energy Telecommunications & Electrical Association (1928) Box 90911, Houston, TX 77090 (713) 893-3666 Exec. Man.: R. A. Maybury Members: 125-130 companies, 850 individuals AB: $25-50,000 Staff: 1 Publ: Newsletter	12/3/80
Community Antenna Television Ass'n. (1973) Suite 106, 4209 NW 23rd St., Oklahoma City, OK 73121 (405) 947-4717 Exec. Dir.: S. Effros Members: 500 systems, 50-60 associates	12/3/80
Aerospace & Electronic Systems Soc. (1965) 345 East 47th St., New York, NY 10017 (212) 644-7910 Members: 4,500-5,000 Staff: 1 AB: $25-50,0000 Note: Subgroup of IEEE. Companies and individuals working on development of earth and space electronic systems.	12/8/80

Name and Address	Date Contacted
Aerospace Medical Ass'n. (1929) Washington Nat'l. Airport, Washington, D.C. 20001 (703) 892-2240 Exec. VP: Rufus R. Messberg, M.D. Members: 50-60 companies, 3500 individuals, 11-15 organizations AB: $100-250,000 Staff: 6-10 Publ: Aviation, Space and Environmental Medicine	11/3/80
Aeronautical Navigator Ass'n., Inc. (1974) 640 Brumbaugh Dr., New Carlisle, OH 45344 (513) 849-6082 Sec.: Major Leland H. Williams Members: 1,000-1,200 Staff: 1 AB: Under 10K Publ: Navigator Newsletter	12/8/80
Airline Employees Ass'n. International (1952) 5600 South Central Ave., Chicago, IL 60638 (312) 767-3333 Pres.: Victor J. Herbert Members: 15,000 Staff: 35 AB: $1-2 million Note: Broke away from Air Line Pilots Ass'n. in 1963	12/8/80
Air Traffic Control Ass'n., Inc. (1956) Suite 409, Arba Bldg., 525 School St., N.W., Washington, D.C. 20024 (202) 554-9135 Ex. Dir.: Col. Gabriel A. Hartl Members: 2000-2100 Staff: 2-5 AB: $100-250,000 Note: Members are air traffic controllers, aircraft owners, pilots, plane workers, airlines and others Publ: ATCA Bulletin Journal of Air Traffic Control	12/4/80
Aircraft Electronics Ass'n., Inc. (1958) Box 1981, Independence, MO 64055 (826) 373-6565 Exec. Dir.: Monte R. Mitchell Members: 350-400 Staff: 2-5 AB: $100-250,000 Note: Companies engaged in manufacture, installation, and servicing of aviation electronic equipment.	12/8/80
Aircraft Owners and Pilots Ass'n. (1939) 7315 Wisconsin Ave., Bethesda, MD 20015 (301) 654-0500 Pres.: John L. Baker Members: 235,000 Staff: 165 AB: over $5 million Note: Absorbed National Pilots Ass'n. in 1979.	12/5/80

Name and Address	Date Contacted
American Academy of Stress Disorders (1970) 8 S Michigan Ave., Chicago, IL 60603 (312) 263-7343 Exec. VP: Jules H. Masserman, M.D. Members: 250-3000 Staff: 1 AB: Under 10K Note: Formerly (1973) Am. Acad. of Air Traffic Control Medicine Publ: Stress Newsletter, Annual of Stress Disorders.	12/8/80
American Helicopter Soc., Inc. (1943) 1325 18th St., N.W., Suite 103, Washington, D.C. 20036 (202) 659-9524 Exec. Dir.: Ms. Lynn Kesten Members: 3900 individuals, 56 companies AB: $250-500,000 Staff: 2-5	12/5/80
Ass'n. of Local Transport Airlines (1957) Suite 803, 1801 K St., N.W., Washington, D.C. 20006 (202) 638-5600 Pres.: Robert Ginther Members: 11-15 shorthaul lines Staff: 2-5 AB: $100-250,000	12/5/80
General Aviation Manufacturers Ass'n. (1943) Suite 517, 1025 Connecticut Ave., N.W., Washington, D.C. 20036 (202) 296-8848 Pres.: Edward Stimpson Members: 33 companies Staff: 11-15 Note: Members are manufacturers of light airplanes, accessories and components.	12/4/80
Institute of Navigation, Inc. (1945) 815 15th St., N.W., Washington, D.C. 20005 (202) 783-4121 Ex. Dir.: Emmett DeAvries Members: 3,000 Staff: 2-5 AB: $50-100,000 Note: Individuals interested in advancing science of navigation on air, land, and sea.	12/4/80
International Ass'n. of Machinists & Aerospace Workers (1888) 1300 Connecticut Ave., N.W., Washington, D.C. 20036 (202) 857-5200 Pres.: William W. Winpisinger Members: 925,000 Staff: 225-250 AB: Over $5 million (i.e., $65 million)	12/4/80

Name and Address	Date Contacted
National Ass'n. of Air Traffic Specialists, Inc. (1960) 415 Wheaton Plaza North, Wheaton, MD 20902 (301) 946-0882 Pres.: Lawrence Cushing Members: 2,500 Staff: 6-10 AB: $250-500,000	12/4/80
Aviation Maintenance Foundation, Inc. (1972) Box 739, Basin, WY 82410 (307) 568-2466 Dir.: Richard Skost Members: 6-7000 individuals, 20-30 companies AB: $100-250,000 Staff: 2-5 Note: Members are aircraft maintenance personnel	12/8/80
Aerial Biosensing Ass'n. (1979) City Nat'l. Bank Bldg., Omaha, NB 68102 (402) 333-9030 Exec. Sec.: Cal Kuska Members: 50-75 Staff: 1 AB: Under 10K Note: Members are companies, educational institutions, and others interested in improving infrared crop monitoring.	12/8/80
Ass'n. of Aviation Psychologists (1964) 3662 Katella, Suite 213, Los Alamitos, CA 90720 (213) 430-5648 Pres.: Dr. Robert Besco Members: 225-250 Staff: 1 AB: Under $10K	12/8/80
Ass'n. of Flight Attendants (1958) 1625 Mass. Ave., N.W., Washington, D.C. 20036 (202) 328-5400 Pres.: Mrs. Patricia Miller Members: 21-22,000 Staff: 30-35 AB: $2-5 million	12/4/80
Commuter Airline Ass'n. of America (1975) Suite 700, 1101 Conn. Ave., N.W., Washington, D.C. 20036 (202) 857-1171 Exec. Dir.: Duane H. Ekedahl Members: 150-200 companies Staff: 6-10 AB: $100-250,000	12/5/80
Flight Engineers International Ass'n. (1948) 905 16th St., N.W., Washington, D.C. 20006 (202) 347-4511 Pres.: William A. Gill, Jr. Members: 1,700-1,800 Staff: 2-5 AB: $100-250,000	12/4/80

Name and Address	Date Contacted
Professional Air Traffic Controllers Organization (1968) 444 North Capitol St., N.W., Washington, D.C. 20001 (202) 638-5000 Pres.: John F. Leyden Members: 14-15,000 Staff: 25-30 AB: $1-2 million	12/4/80
American Pilots Ass'n. (1884) (Ships) Suite 404, 1055 Thomas Jefferson St., N.W., Washington, D.C. 20007 (202) 333-9377 Pres.: Capt. Patrick Neely Members: 50-60 state ass'ns. of pilots AB: $10-25,000 Staff: 205	12/5/80
International Passenger Ship Ass'n. (1972) 17 Battery Place, New York, NY 10004 (212) 425-7400 Exec. Officer: William J. Armstrong Members: 8-10 companies Staff: 2-5	12/8/80
Professional Airways System Specialists 444 N. Capitol St., N.W. Washington, D.C. (202) 347-6065	02/12/81
Federal Aviation Science and Technology Association 2139 Wisconsin Ave., N.W. Washington, D.C. (202) 965-4411	02/12/81
National Association of Broadcasters 1717 N Street, N.W. Washington, D.C. (202) 293-3558	01/20/81
Clinton Cox NIOSH-Environmental Surveillance Cincinnati, OH	01/29/81
Montaz Wassas NIOSH Rockville, MD	12/16/81
Robert Shiffman Int. Microwave Power Institute New York, NY	01/28/81

Name and Affiliation	Date Contacted
Mr. Wilson Field Operations Bureau Federal Communications Commission (FCC) 1919 M Street, N.W. Washington, D.C. 20554	02/4/81
Ms. Mulls Antenna Survey Branch Federal Communications Commission (FCC) 1919 M Street, N.W. Washington, D.C. 20554	02/9/81
Chet Lament Labor Management Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591	02/12/81
Jan Marshall Personnel Office Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591	02/17/81
Frieda Johnson Airways Facility Services Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591	02/12/81
Mr. Shipman Obstruction of Airspace Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591	02/9/81
George Berzins Engineering Department Voice of America 330 Independence Avenue, S.W. Washington, D.C.	02/9/81
Mr. Grady Federal Protective Service General Services Administration (GSA) F Street, N.W. Washington, D.C.	02/19/81

Name and Affiliation	Date Contacted
Quinton Lawson Federal Protective Service General Services Administration (GSA) F Street, N.W. Washington, D.C.	02/20/81
Al Zitel National Park Service C Street, N.W. Washington, D.C.	02/20/81
Mr. Colatrite Protection Division Smithsonian Institution 1000 Jefferson Drive, S.W. Washington, D.C.	02/20/81
Laurie Anderson Personnel Department Secret Service 1800 G Street, N.W. Washington, D.C.	02/20/81
Captain Bell Security Department Capitol Police New Jersey & Independence Ave., S.E. Washington, D.C.	02/20/81
Captain Romanelli Security Department Library of Congress 1st Street, S.E. Washington, D.C.	02/20/81
Dr. Michael Gregg Center for Disease Control Atlanta, GA 30333	02/24/81
Dr. Gracen Miller Virginia State Health Department Richmond, VA	02/24/81
Dr. Polly Roberts Maryland State Health Department 201 West Preston Street Baltimore, MD 21201	02/24/81
Dr. Sylvia Auton Fairfax County Public Schools Wilton Wood Center 3701 Franconia Road Alexandria, VA 22310	02/24/81

Name and Affiliation	Date Contacted
Irene Addo Maryland State Health Department 201 West Preston Street Baltimore, MD 21201	02/25/81
George Hammill Fairfax County Public Schools, Community Relations 10700 Page Avenue Fairfax, VA	02/23/81
Frank Elliot Fairfax County Public Schools, Records Management 10700 Page Avenue Fairfax, VA	02/23/81
Martha Willes Federal Emergency Management Agency (FEMA) Olney Computer Center Olney, MD	02/23/81
Mr. Lawson Federal Emergency Management Agency (FEMA) Olney Computer Center Olney, MD	02/23/81
Imelda Hodge National Center for Statistics Department of Education Washington, D.C.	02/24/81
U.S. Geological Survey 507 National Center Reston, VA 22092	02/27/81
Officer McDell Fairfax County Police 10600 Page Avenue Fairfax, VA	02/18/81
Captain Keefer Motor Squad Fairfax County Police 10600 Page Avenue Fairfax, VA	02/18/81
Maryland State Police Pikesville, MD	02/19/81
Sgt. Darris Delaware State Police Dover, DE	02/19/81

Name and Affiliation	Date Contacted
Lt. Weyland Virginia State Police Richmond, VA	02/18/81
Mr. White Virginia State Police Richmond, VA	02/27/81
Janet Bowman County Health Dept. Portland, OR	01/26/81
Mr. Greenberg FM Broadcasting Federal Communications Commission (FCC) 1919 M Street, N.W. Washington, D.C. 20554	02/9/81
Antenna Inc. Cleveland, OH	01/29/81
AEL Inc. Landsdale, PA	01/29/81
RCA Service Co. Camden, NJ	01/30/81
Anixter-Mark Des Plaines, IL	01/30/81
Bel-Tronics Corp. Addison, IL	01/30/81
Chisholm-Ryder Co. Inc. Niagara Falls, NY	01/30/81
Chu Associates, Inc. Littleton, MA	01/30/81
Cincinnati Electronics Corp. Cincinnati, OH	01/30/81
Com Associates, Inc. Huntington Station, NY	01/30/80
Compagnie Generale de Telecommunications International White Plains, NY	01/30/81
Conrac-Telex Lincoln, NB	01/30/81

Name and Affiliation	Date Contacted
Cushcroft Corp. Manchester, NH	01/30/81
Stainless, Inc. North Wales, PA	01/28/81
Unarco-Rohn Peoria, IL	01/28/81
Kline Iron & Steel Co., Inc. Columbia, SC	01/28/81
Brooks Erection Co. Reidsville, NC	01/28/81
Southern Tower Norfolk, VA	01/28/81
Robinson Tower Company Greenville, NC	01/28/81
National Steel Erectors Wiscogee, OK	01/28/81
Ellis Tower Ft. Lauderdale, FL	01/29/81
Tower Systems Isanti, MN	01/29/81
Hamilton Erection Co. York, SC	01/29/81
Nudd Corp. Ontario, NY	11/30/80
Antenna Research Associates Beltsville, MD	01/29/81
Micab Millburn, NJ	02/2/81
General Electric Springfield, VA	02/27/81
RCA Washington, DC	02/27/81
Motorolla Inc. Arlington, VA	02/27/81

Name and Affiliation	Date Contacted
Bell Telephone Sommerset, NJ	01/20/81
Mutual Broadcasting Company Washington, DC	02/13/81

APPENDIX D

Experts in Radiofrequency Radiation

Name and Affiliation	Date Contacted
W. Ross Adey Jerry L. Pettis Memorial VA Hospital Loma Linda, CA 92357	01/15/81
Ernest Albert George Washington University Medical Center Washington, D.C. 20337	01/15/81
Robert Albrecht BRH-FDA Rockville, MD	0/1/5/81
Stewart J. Allen USAF SAM/RZP Brooks AFB, TX 78235	01/15/81
T. Whit Athey #44-33840 Division of Electronic Products Branch EMB Building T7, Room 705 BRH, FDA	01/14/81
Howard F. Bassen BRH, FDA 12721 Twinbrook Parkway Rockville, MD 20857	01/15/81
Paul Brodeur New Yorker Magazine New York, New York	01/19/81
Augustine Y. Cheung University of Maryland Baltimore, MD	01/12/81
G. K. Chou University of Washington Seattle, WA	01/16/81
Howard Clark National Bureau of Standards Gaithersburg, MD	01/08/81
Robert Cleveland Federal Communications Commission (FCC) 2025 M Street, N.W. Washington, D.C. 20554	01/15/81

APPENDIX D (continued)

Name and Affiliation	Date Contacted
Jules Cohen Jules Cohen & Associates 1730 M Street, N.W. Washington, D.C.	1/23/81
Dr. David Conover, Physical Agents National Institute for Occupational Safety and Health (NIOSH) 4676 Columbia Parkway Cincinnati, OH (513) 684-8482	01/05/81
Robert Curtis Salt Lake City, UT OSHA Environmental Lab. FTS - 588-5896	01/06/81
Carl H. Durney Department of Electrical Engineering University of Utah Salt Lake City, UT 84112	01/16/81
Steve Fewell FAA	01/08/81
Kenneth R. Foster University of Pennsylvania Department of Bioengineering Philadelphia, PA 19104	01/19/81
Allan H. Frey Random Line, Inc. County Line and Mann Roads Huntingdon Valley, PA 19006	01/14/81
Arthur Guy Bioelectromagnetics Research Laboratory Department of Rehabilitation Medicine University of Washington Seattle, WA 98195	01/13/81
Dr. Robert Harris University of North Carolina Chapel Hill, NC	12/08/80

APPENDIX D (continued)

Name and Affiliation	Date Contacted
Janet Healer Program Manager, Non-ionizing radiation National Telecommunications and Information Administration 1325 G Street, N.W. Washington, D.C. 20005 FTS 724-3301, Commercial (202) 724-3301 Biological Effects of Non-ionizing Electromagnetic Radiation Task Force Interagency "Side Effects" Working Group on the Biological Effects of Non-ionizing Radiation of the Interdepartment Radio Advisory Committee	01/12/81
Ed Hunt Walter Reed Army Institute of Research Washington, D.C.	01/15/81
K. Illinger Department of Chemistry Tufts University Medford, MA 02115	01/16/81
Magdy Iskander Department of Electrical Engineering University of Utah Salt Lake City, UT 84112	01/16/81
David Janes Office of Radiation Programs Environmental Protection Agency (EPA) P.O. Box 15027 Las Vegas, NV 89114	01/19/81
Don R. Justesen VA Medical Center University of Kansas Medical Center 4801 Linwood Boulevard Kansas City, MO 64128	01/16/81
Terry Leet NIOSH, Cincinnati, OH FTS - (513) 684-2761	01/29/81
James C. Lin University of Illinois Bioengineering Program Chicago, IL 60680	01/15/81

APPENDIX D (continued)

Name and Affiliation	Date Contacted
Charles Lomus Multiple Braodcast Antenna Commission Chicago, IL	1/22/81
James L. Lords University of Utah 4190 Sovereign Way Salt Lake City, UT	01/16/81
Stephen Lynn FM Broadcasting Division Federal Communications Commission (FCC) 1919 M Street, NW Washington, DC 20554	01/06/81
Arthur Massara Microwave Research Foundation	01/16/81
James H. Merritt USAF SAM/RZP Brooks AFB, TX 78235	01/13/81
Sol Michaelson Department of Radiation Biology and Biophysics School of Medicine and Dentistry University of Rochester Rochester, NY 14642	01/15/81
Saul Miodownik Sloane-Kettering Memorial Hospital Biomedical Engineering Department, Electronic Devices New York, NY	01/20/81
John C. Mitchell USAF SAM/RZP Brooks AFB, TX 78235	01/16/81
Richard G. Olsen NAMRL Code L33RO Naval Air Station Pensacola, FL 32508	01/14/81
Paul Rich FAA Washington, D.C.	01/13/81

APPENDIX D (continued)

Name and Affiliation	Date Contacted
Dr. Dennis Robinette National Academy of Sciences 21st Street and Pennsylvania Avenue Room 616 Washington, D.C. (202) 389-6467	11/03/80
Stephen Ross Spec Relief and Microwave Division Federal Communications Commission (FCC) Cable Television Bureau 2025 M Street, N.W. Washington, D.C. 20554 (202) 632-8882	01/06/81
Thomas C. Rozzell and Elliot Postow Office of Naval Research 800 North Quincy Street Arlington, VA 22217	01/14/81
Paul S. Ruggera #44-33840 Division of Electronic Products Branch EMB Building T7, Room 704 BRH, FDA	01/15/81
Dr. Charlotte Silverman #44-32356 Deputy Director Division of Biological Effects Branch OD Building TR, Room 2A BRH, FDA	01/13/81
Joseph Sirkus FAA	01/08/81
Richard S. Sternchak (44)3-3426 Division of Compliance, Branch S+RB Building T, Room 122 BRH, FDA (Licensing and Approval)	01/06/81
Jean and Steven Stellman American Cancer Society and Columbia University New York, NY 10017	12/30/80

APPENDIX D (continued)

Name and Affiliation	Date Contacted
Dr. Paul Strudler, Epidemiologist HEW, NIOSH, OPPE Parklawn Building, Room 8A09 5600 Fishers Lane Rockville, MD 20857	01/16/81
M. A. Stuchly Radiation Protection Bureau Health and Welfare Canada Room 233 Environmental Health Ottawa, Ontario, Canada K1A 0L2	01/20/81
S. S. Stuchly Department of Electrical Engineering University of Ottawa 770 King Edward Avenue Ottawa, Ontario, Canada K1N 6N5	
Richard Tell Office of Radiation Programs, EPA Electromagnetic Radiation Analysis Branch P.O. Box 18416 Las Vegas, NV 89114	01/06/81
Dr. Robert Thompson Occupational Safety Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591	2/11/81
Joseph Towne Radar Victims Network	01/15/81
Pat Utrollo MCI Telecommunications Corporation 1150 17th Street, N.W. Washington, D.C.	07/6/81
Larry Williams, Radar-Automation Engineering Division Federal Aviation Administration (FAA) 800 Independence Avenue, S.W. Washington, D.C. 20591 (202) 426-3118	01/06/81